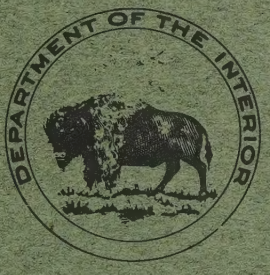
The PROGRESSIVE FISH-CULTURIST

NOVEMBER—DECEMBER 1939



UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF FISHERIES
WASHINGTON

PROGRESSIVE FISH-CULTURIST

ISSUED BY THE

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BUREAU OF FISHERIES - - - - - - - - - - - - CHARLES E. JACKSON, ACTING COMMISSIONER

A SERIAL memorandum published occasionally for the advancement of fish culture and fishery management in fresh waters.

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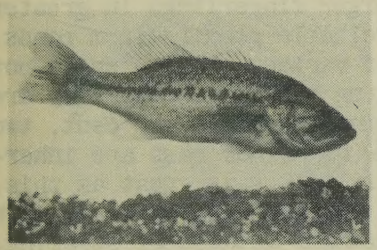
The PROGRESSIVE FISH-CULTURIST

News and Views from many Sources on Practical Hatchery Problems

Memorandum I-131 Washington, D. C. November-December 1939 No. 47

A METHOD FOR THE PRODUCTION OF LARGEMOUTH BASS ON NATURAL FOOD IN FERTILIZED PONDS

By O. Lloyd Meehean
U. S. Fisheries Station, Welaka, Florida



PRODUCTION OF largemouth black bass at a given station is unpredictable. The average fish-culturist cannot depend upon uniform production in two ponds side by side with conditions apparently alike in every way. One pond may yield five thousand fish and the one next to it only five hundred. This without exaggeration is an everyday occurrence. There has been some improvement in the last four or five years, but the best fish-culturists are still puzzled over the erratic way in which ponds are wont to act. Cannibalism is taken for granted. Fish of large size are proudly displayed in an attempt to assuage the hurt caused by smaller numbers. Bream are produced far beyond the public demand to pacify the consciences of the hatchery men over their seeming inability to cope with the eccentricities of nature in rearing bass. Per acre production of bass and their size is sacred ground upon which another dare not tread. If you think this is exaggerated, try to elicit some information from the first hatchery man you meet and the most loquacious of them will become taciturn.

The reason behind all this strange behaviour is that no one has worked out the problems which are basic in overcoming cannibalism. Fish-culturists are impatient and feel that production is being impeded if immediate results are not produced by scientific investigators. With them it is an abracadabra sort of thing. They are not conscious of the fact that results from such a study are dependent upon the vagaries of nature and not produced at will as a series of chemical experiments might be. It has not been realized that many problems such as the social reactions of the fish, how they feed, how the food organisms are produced, what food chain from the organic compounds to fish are the most beneficial, what fertilizer will best stimulate this food chain, must first be solved in order to know what is happening. In other words, one must get the fundamentals of the reactions of the fishes and their relation to food in order to offer an intelligent solution to the problem. We are still a long way from that final solution.

The problem of the production of largemouth bass to meet public demand is becoming more and more acute. As a result in the last few years, the tendency at many hatcheries is toward the production of numbers of fish regardless of size. Excessive demands by the public, and the favorable comments from papers and administrative sources have fostered this trend. By this I refer specifically to so-called "inch fingerlings." Production of fish of this size in a pond is only limited to the number of brood stock that can be maintained in the body of water.

This quantity output fills a supposed need, but the desirability of numbers of such fish is questionable. The public is of the firm opinion that a large number of fish is the solution to the problem of stocking our fishing waters, but there are many other factors involved. These include intricate relationships between fishes of various species, their food and their environment. This is attested by the about face of the various conservation departments in the more up-and-coming states or in regions where the pressure of public demand requires an investigation into apparent failures of large scale stocking of various bodies of water.

Our experimental work with fertilizers is directed toward the solution of one phase of this problem, namely, the production of larger fingerlings in greater numbers more economically, and with more assurance of reliable results from ponds. But let us first look at the mortality rate for fish of various sizes. We do not have tables for bass at present, but for trout, according to Dr. Embody, they are as follows. In a planting of one inch trout, the survival is 5 per cent, two inch fish 20 per cent, and three inch fish 50 per cent. Since bass are inherent cannibals and voracious feeders, I doubt if the survival is as great as this. Therefore, it is highly desirable to stock lakes and streams with as large fish as possible, especially in view of the present haphazard methods of stocking.

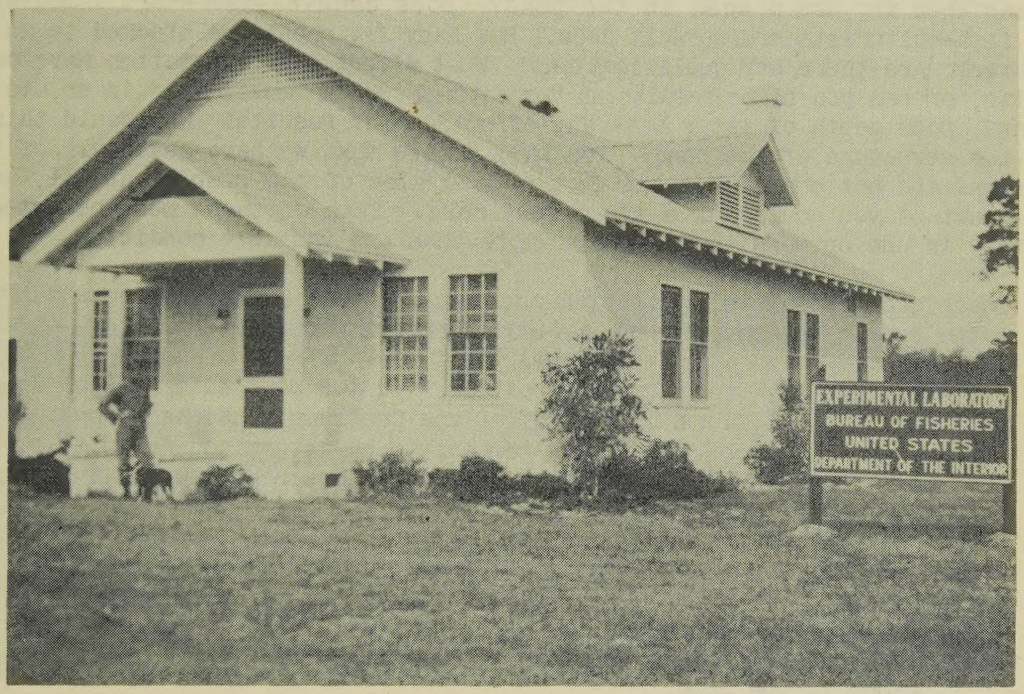
Theoretically, there are three possible ways in which fish may acquire their food under artificial conditions. They may be made to maintain themselves upon natural food in the pond as we do with our largemouth bass in many instances. Secondly, forage fish may be included in the pond. This should result in an adequate increase in the number of pounds of fish produced per unit area. And last, we may feed by hand as we do with trout and in this way increase the production of a unit area of water to a point where space becomes the limiting factor rather than food.

Methods for the production of largemouth bass have not undergone any fundamental changes since the artificial propagation of the species started. Innovations and improvements in methods for the production of smallmouth bass have reached a point where hand feeding has become the most satisfactory. To my knowledge, hand feeding of largemouth black bass is practiced successfully in only one instance. It is practical only because the citizens, in order to obtain legal size fish for overburdened streams, are willing to pay the cost of the large amount of labor involved.

In our hatcheries today the same old debate goes on as to the number of brood fish to be used on an acre of water, the number of fry to stock in a certain area, whether or not vegetation is good for the ponds, and the value of forage minnows of various species and in various numbers. However, it is the same debate that has gone on since the introduction of artificial methods.

This paper will confine itself to the use of natural food and the use of fertilizers as an adjunct to pond production of the largemouth bass. The experiments have not reached beyond this stage although they were started in 1932 and carried through 1936. It has taken a long time to arrive at definite conclusions because it was first necessary to work out the ecology of the pond with special regard to the type of fertilizer best suited to the job and then to the various factors that might have a bearing on the production in the pond aside from the food problem. That is, we must find out why things happen in order to prevent their occurrence or cause them to occur persistently.

Until recently most investigators have contented themselves with putting some fertilizer in the pond and measuring the amount of plankton produced. Where



Laboratory at the U. S. Fisheries Station, Welaka, Florida

the most plankton was measured, there was the best fertilizer for raising fish. Nothing was said of the fish themselves, or the amount of fish flesh produced per unit area in the ponds, or whether success depended upon any other factors than plankton. There is a woeful lack of such information. Many people have also made various and sundry estimates of the productive capacity in various bodies of water under hatchery conditions. Some of these estimates would tickle the fancy of the most gullible and some would please the most skeptical. Few are of any practical value.

Let us glance hastily at the broader aspects of the problem. First we are conscious that a definite amount of fish flesh is produced on an acre of water,

and that it is in proportion to fertility, just as with farm land, but we still cannot measure that fertility. What the upper limit is no one knows definitely. A single species (as in this case) is no criterion, for it does not utilize the food to the fullest extent possible if placed in the pond alone. I have been able to produce about 110 pounds of bass consistently per acre of water. However, that is not necessarily the limit of total fish flesh for it takes a number of species of diverse feeding habits to utilize all of the food in the pond.

If we confine the problem to largemouth bass alone it would follow somewhat along these lines. First, what is the food chain involved that will yield the quickest results? Later I shall show that the element of time has very important relation to successful results and maximum yield. After the food chain has been worked out, which fertilizer will induce the maximum food production in this chain in the shortest time and most economically? How much should be used? What happens when fry are placed in the pond? Does cannibalism start immediately? Some fish-culturists are sure it does. How many fry should be stocked to an acre of water? Are there any qualifications? What effect does vegetation have on the results, or can you blame results on vegetation? Is it beneficial; if so, to what extent? Does depth of water have any effect on the results? How would this affect the structure of the pond? You will notice that we have asked all of these questions and not considered the forage food side of the problem at all, and no doubt most of you could ask a great many more. Each of these must be tried separately in one or more ponds with no more than one variable condition.

These questions have to do with the first phase of the problem which is as far as the results of the present series of experiments have extended.

1. The ecology (sociology) of the bass in the pond with natural food, and his relationship to many of the problems mentioned above. The exact amount of fertilizer remains to be determined definitely, and only the high spots in these questions have been touched in the experimental work.

Other subjects requiring investigation are:

2. The ecology of the sunfish or each of the other types of forage fish in relation to the pond conditions; each separately and alone in the pond.

3. The ecology of these forage fish in various combinations without any bass in the pond.

4. The ecology of the pond with bass and the various forage fish combinations that promise good results.

Only the first problem is partially answered. It is absolutely necessary in a problem of this kind to teach each question separately as the single variable in the pond and to keep all other things constant. Height of water, amount of vegetation, method of stocking, number and size of fry, possible overflow, shape of pond, and any number of other things that may have effect upon the results must all be under control. For this reason the information has been carefully sifted over a period of six years and results from just a few of the ponds were actually used.

The experiments this year were consolidated from information pieced over this length of time, acquired at a number of stations in a number of states and under various circumstances. It is well to remember that all of the information has been gathered in the south so that there may be certain exceptions in more northern sections. It is felt, however, that the recommendations given here will be helpful under all conditions if they are applied judiciously.

STRUCTURE OF THE POND

First let us consider pond structure and its bearing upon production results. All ponds should be constructed so that they are at least 18 inches deep at the shallow end, although 2 1/2 to 3 feet would not be amiss. They should at

Bass ponds at the Welaka station built by the State of Florida before the station was taken over by the Resettlement Administration and then transferred to the Bureau of Fisheries.

least be this deep because there is a tendency for vegetation to clog the shallow end making it impossible for the fish to forage it. I have seen ponds where numbers of mosquito larvae could be dipped up at any time although the pond was well stocked with bass and bream.

In the deep South, if a pond is too shallow at one end, the accumulation of vegetation causes the water to stagnate so that the temperature may reach 90 or 95 degrees F. It is impossible for fish to forage under such conditions, but such a condition exists in at least one station to my knowledge.

The last reason for greater depth at the shallow end of the pond is that at stations where it is necessary to pump water, it is not economical to start and stop a pump too often. As a result these shallow sections of the ponds get into just such a condition as mentioned above. It is beyond the control of the operator to do anything about such limitations without unjustified pumping expense. I have used ponds of this nature for experimental work, and have felt that production was about two-thirds what it should have been under other circumstances. It is estimated that up to one-third the area of such ponds is lost to production, although there is water covering the bottom.

PREPARATION FOR STOCKING THE POND

Probably we have all reached the same conclusion regarding the value of rearing and brood ponds, although the latter have not been thoroughly investigated. A bass is the most voracious feeder there is, so that the fish-culturist's problem is made doubly hard. If adults are used in combination with fingerlings in the pond, the number of adults should be as few as possible per acre. The best result, which is comparable to figures obtained in rearing ponds, was from a pond stocked with three females and two males per acre. The alternative is to produce so-called inch fingerlings in brood ponds.

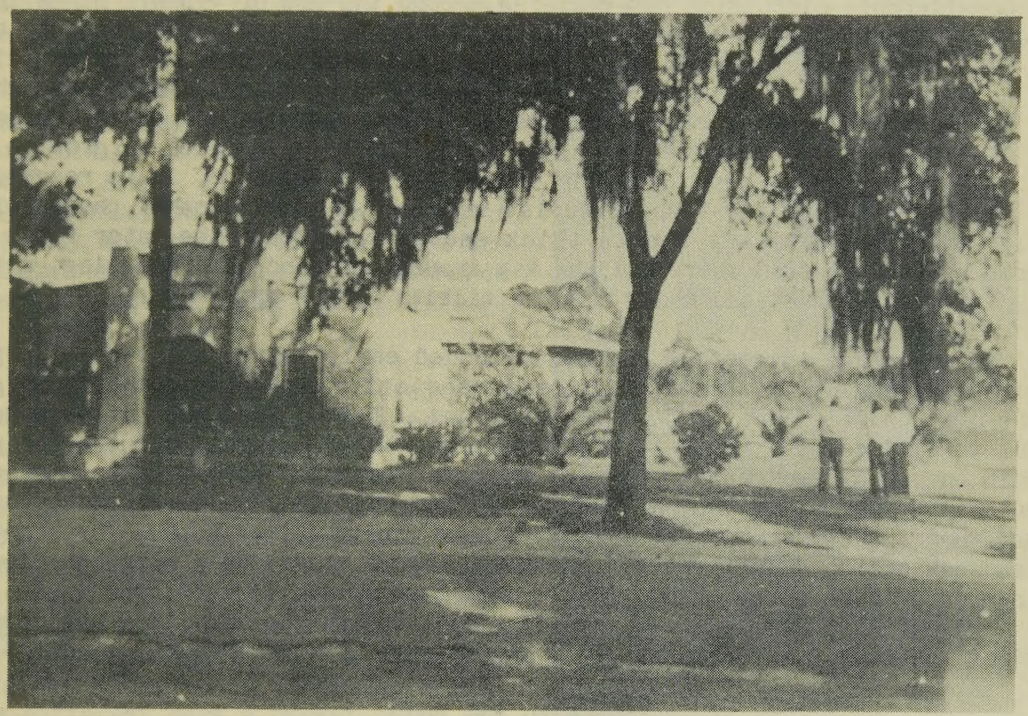
Most hatchery men use separate rearing and brood ponds. If this method is used it is preferable that the rearing ponds be left dry during the winter. This gives land vegetation an opportunity to convert the unavailable fertilizing material in the bottom of the pond into available plant material that will decay and add to the fertility during the course of the following season. It also gives an opportunity for the sterilization of the bottom by removing diseases and parasites that may spend part of the life cycle there. On the other hand, it is detrimental because it kills the larger insect larvae that serve as food for larger fingerlings. We, therefore, consider it very essential that the pond be filled and fertilized for some time before the fry are to be transferred.

The ponds should be filled with water from one month to six weeks before the fry are transferred to them. This allows the organic matter in the pond to decay and induces a luxuriant growth of daphnia and other aquatic microscopic organisms so that they have a head start on the fry.

The food cycle from the organic matter to the fry is principally an all-animal cycle as far as bass are concerned. Therefore, there must be some type of organic matter available for the bacteria, which in turn are fed on by higher organisms. This does not discredit the value of a water bloom as advocated by the Germans and many American investigators, but bloom is not essential.

It is for this reason we advise that the plant material from the preceding season be stacked in or around the edges of the pond so that the organic matter, which also contains other nutrient substances, may be leached back into the water. Otherwise a part of the fertility of the pond is removed with the vegetation as well as with the fish crop, thus necessitating the use of more fertilizer than would otherwise be the case. Any vegetation that can be induced to grow in the dry pond will be just that much fertilizer to the good when the pond is flooded. We have all seen clouds of daphnia around such vegetation in newly flooded ponds and are acquainted with the peculiar success the first year. It is due to the amount of organic matter present, mostly from land vegetation decaying in the water.

The commercial fertilizer best adapted to the production of largemouth black bass in this section and by this method is cotton seed meal. It is an organic fertilizer inducing a rapid pickup in the reproductive cycle of the food organisms, and containing most of the essential elements necessary for fish and other life. Many types of fertilizer have been tried in our experiments over a period of years, including such things as sheep manure, dried blood meal, meat scrap, alfalfa meal, superphosphate, sodium nitrate and others. Some are good but too expensive, others have a depressing effect upon the bottom fauna. Such is the case with superphosphate. Some are not concentrated enough to bring about the accumulation of organic matter necessary for good results. Fresh stable manure and liquid cow manure which give very good results are not available in this section.



Public aquarium at the Welaka station built by the C.W.A. for the State of Florida and now Bureau property.

The ponds should be fertilized weekly beginning four weeks before the time the fry are to be transferred. The exact time is a matter for each one to decide for some ponds may require longer to build up the plankton sufficiently. We had just as good results this year starting barely two weeks ahead of the transfer. Fifty pounds of fertilizer should be broadcast over the surface of the water during the first two weeks for every acre of water, and the acreage is not measured to the center of the dike. Overfertilization may kill fish and underfertilization produces cannibals.

Fertilization at this rate should continue for about four weeks, provided a water bloom does not become apparent. In such a case the amount may be cut in half or eliminated entirely for a week, because a heavy water bloom may cause an oxygen deficiency due to the decaying microscopic algae and because it takes oxygen from the water at night. The object is not necessarily to produce a water bloom since good results will be obtained without it.

A total of about 300 pounds of meal should be used per acre during the season. We used 350 pounds this year as a minimum, but it is estimated that 300 pounds will accomplish the same results. A series of experiments will be run next year to determine the exact amount. It may take two or three years to build up the fertility of a series of ponds.

Considerable discussion has centered around the use of Daphnia magna in the ponds. If they can be started and the pond can be handled properly they are a very fine thing, but they are sensitive to higher temperatures and it is difficult to work them into the pond ecology in Southern climates. The waters wherever you go abound with various species of native daphnia and other crustacea, some of which reach a considerable size. They can be induced to grow in tremendous numbers in the pond by using fertilizer. Therefore, it is recommended that the attention of the fish-culturist be directed toward other phases of the problem. Native forms may become thick enough to darken the water for a considerable distance from shore all the way around the pond with crawling, active, semi-microscopic crustacea which are the tidbits of the bass fry.

The advantage in getting the pond flooded early serves a two-fold purpose. It gives the organic material from dead vegetation and plants that have grown in the dry pond a chance to become stabilized. This allows the nitrogenous material to diffuse into the water from this vegetable material without too great a drain on the oxygen supply when the fry are present. It gives the microcrustacea an opportunity to increase in numbers so that they will reproduce rapidly enough when the fry are put in the ponds to maintain a food supply for sometime. The success of the fertilization procedure may be gauged to a certain extent by the number of back swimmers and water boatmen around the edges of the water. The more abundant they are, the more abundant is the fish food for they are competitors for the same food organisms used by the fry.

STOCKING THE POND

After the pond is prepared properly the next step is stocking. It is imperative that two things be observed when this stage is reached. In the first place, the greatest loss of fry takes place immediately. An experiment at Natchitoches, Louisiana, in a small pond which could easily be controlled showed that there was a loss of almost 20 per cent during the first month and in that time the fish grew to 2.08 inches. Growth from that time on was in proportion, somewhat, to the decrease in numbers in the pond.

All fry must be of the same size when stocked. That is, the containers for each pond must be placed side by side and the fish picked from schools in such a manner as to get all fry exactly the same size. This is imperative. For example, Pond 1 of the experimental unit at Welaka was stocked for a second time with bass fry this season, but it was the latter part of the season and all fry could not be selected to match in size. When the pond was drained it produced only 7,177

fish per acre whereas the first crop of the year in this pond was nearly 13,000 fingerlings per acre.

Let us explain it in another way with another example. The first time the pond was stocked the fry were all of the same size. At the end of thirty days they averaged 2 inches in length and ranged in a measured sample only 1/2 inch difference in length from the largest to the smallest. The second time it was stocked, fry of two sizes were used and at the end of thirty-two days the fry averaged 2.11 inches and ranged over 1 5/8 inches in extreme length. When the pond was drained at the end of forty-nine days the fingerlings averaged 2.6 inches and ranged over 1 7/16 inches. In other words, they were potential cannibals. These are not as extreme cases as are found at most hatcheries but they serve to show the point.

A second precaution when the ponds are being stocked is to see that each is completely stocked at one time. Where fertilizer is being used the fry may grow considerably overnight, or at least they will have recovered from the handling before the others get a chance to feed and one day makes a big difference in size.

Of three ponds partially stocked on different days this year on the experimental areas, one was sampled at the end of 39 days and the fish measured. The range in size was from 1 1/2 to 4 1/8 inches. It was drained immediately because this discrepancy was detected. It produced 12,715 fish per acre averaging 2 3/8 inches. If we had waited, the results would have been disastrous. In the two other ponds partially stocked on different days a bucket of fry was held over for comparison. As a result, the extreme difference in length was not found when the fingerlings were measured after one month, but still it was greater than in any of the other ponds stocked all at one time. Human judgment is no substitute for actual measurements. If ponds, partially stocked on separate days without actual measurement of the fry, are allowed to remain for two or three months the production will be extremely small.

Florida costumes for Florida weather. Loading truck with fish sorted and counted into tubs for moving on station grounds.

A last factor in stocking the pond is to use a number of fry per acre somewhat in keeping with the expected production for the ponds in use. Our greatest fallacy has been that we have been thinking in terms of the maximum number to

stock; we should reverse our ideas and think in terms of minimum numbers. Let us again demonstrate with examples. Over a period of a number of seasons at Natchitoches the survival for fingerlings in the experimental ponds under absolute control was 36.1 per cent. The expected production per acre was from 5,000 to 7,000 fingerlings, but actually ranged up to 10,987 in one instance. The ponds were stocked with 17,000 to 25,000 per acre. In the one pond stocked at the rate of 11,842 per acre the survival was 73.78 per cent when the fish reached 2.75 inches at the end of approximately two months.

A second more convincing example in this year's experimental work probably would give a better picture. Pond 1 was stocked at the rate of 15,000 per acre and pond 8 at 20,000 per acre. The expected production was unknown, but I was convinced that 20,000 fry per acre was too many. Pond 1 produced 12,891 fingerlings 2 7/16 inches long for a survival of 85.94 per cent and pond 8 produced 12,715 fingerlings for a survival of 66.12 per cent. Both produced almost exactly the same number of fish, but the survival in one was 20 per cent less than in the other. The survival in pond 8 would have been 84.77 per cent if it had been stocked at the same rate as pond 1. In other words, 5,000 fry were wasted per acre of water in this pond.

Overstocking results in crowding as fish become larger. Competition for food becomes too keen and will result in uneven growth, and finally cannibalism. Contacts are more frequent between the individuals, which also fosters cannibalism. Proper stocking insures an abundance of food in ponds properly fertilized and will insure even growth. It is absolutely essential that the fry be given the advantage of an even start if possible.

The results of pond production for the average fish-culturist are erratic and unpredictable. I am convinced that if sufficient food is present, if the fry are of the same size, and if the pond is stocked at a rate that recognizes the capacity of the ground on which the fish are produced, cannibalism will largely be eliminated and the results from year to year will be uniform. To bear this out in our experimental work this year, the first pond was drained at the end of 50 days and the last one at the end of 138 days. The first one had a survival of 85.94 per cent and produced 12,891 fingerlings 2 7/16 inches in length per acre; the last one a survival of 82.7 per cent and produced 12,409 fingerlings per acre measuring 3 1/4 inches.

I am of the opinion that these figures have approached the maxiumum consistent yield of this size fingerlings that can be produced on an acre of fertilized water with largemouth bass on natural food. It may be that the number can be raised when more is known, but the expected yield for the average hatchery should be somewhat lower than this.

It has been the practice of hatchery operators to use selects for brood stock. Selects are fingerlings which have become much larger than the average of the output, merely because they are cannibals. The criterion by which the operator may determine when he is reaching maxiumum production at his hatchery, is the absence of any selects in the ponds. During the last year of experimental work at Natchitoches, there were no selects. It took three years of work to build up the fertility of the ponds and to determine the reasons for, and to eliminate select stock. We have had none in the experimental ponds where no forage fish were used here this year.

There are one or two suggestions that might be in order. The fingerlings should be brought up to 2 1/2 inches or thereabouts as rapidly as possible. This may be accomplished in about forty days from the time the fry are stocked by the use of the proper amount of fertilizer. It will offset variation in size to a certain extent because it cuts down on the length of time in which cannibalism can occur.

The size of the fry used for stocking is apparently immaterial, except that the schools may reassemble if the fry are too small. This year we were forced to use very small ones in most of our stocking on the experimental area. As a result schools of tremendous size were formed in the rearing ponds after a few days although the fry had been scattered along the whole shore line. If care had not been taken to get those of uniform size together,, we could have expected a nice crop of selects. As it was,although the fingerlings stayed in schools until they were about 1 1/2 inches in length, no harm resulted. Under the usual conditions, if larger fry are used, they spread uniformly over the pond and are not seen for a couple of weeks until the fingerling takes its permanent station in the pond.

One of two things can happen in a pond with fingerlings. The size may be very uniform or it may be variable. This variation is moderate or extreme depending upon the precautions taken when the ponds are stocked. If the size is uniform from the beginning the production at the end of four months should be about the same as at the end of a month or a month and one-half. This is shown in the two examples cited above. The standard deviation of measured lengths or the length range of most of the fish must be very small.

Under ordinary fish-cultural procedure there is usually variation in size from the beginning. Where there is moderate variation, growth is somewhat in proportion to the amount of mortality. That is,in the number of fingerlings produced, the size and survival are related. For example, (see table 1) when pond 8 was drained at the end of 39 days it produced 12,715 fish per acre measuring 2 3/8 inches long for a survival of 84.77 per cent; pond 4 at the end of 71 days produced 10,875 fish 2 9/16 inches long with a survival of 72.5 per cent; pond 3 produced 9,385 fish 3 1/4 inches in length for a survival of 67.7 per cent at the end of 113 days. You can see there is a decrease in survival with increased size.

Table 1. The Relation of Production to Time with Moderate Size variation

Pond	Days	Production	Size	Per cent Survival
8	39	12,715	2 3/8	84.77
4	71	10,875	2 9/16	72.50
3	113	9,385	3 1/4	67.7

If the variation in size is great, we get results which are very common at an average station. That is, one pond produces very few 4 to 6 inch or larger fish, and another, a considerable number of 3 inch fingerlings. From experience

we very well know that when a man talks about the nice 6 or 8 inch fish, he is attempting to comfort himself for his lack of production in numbers. A unit area will produce only a definite amount of fish flesh. If productive capacity is taken up in size, the numbers are few, but if it is taken up in numbers the size may be up to about 2 1/2 to 3 inches. Let us cite an example. In one pond we stocked with a large number of gold fish for forage. At the end of the season we took about 75 fingerlings 12 1/2 inches in length weighing 1 1/3 pounds each and about 450 three inch fingerlings. This is an example of extreme variation. The number of pounds of fish in the pond was the same as in others producing 3,000 to 10,000 smaller fingerlings.

A word of explanation should be given to show how one may detect ponds likely to be successful and those which are not. In our experimental procedure we go into each pond atthe end of one month with a bobbinet seine about fifteen feet long. A short drag is made at any likely place and all of the fish in the seine are measured. One has to be sure he has an adequate number in order to obtain a good curve of the measurements. As the fish become larger they elude the seine and more drags will have to be made.

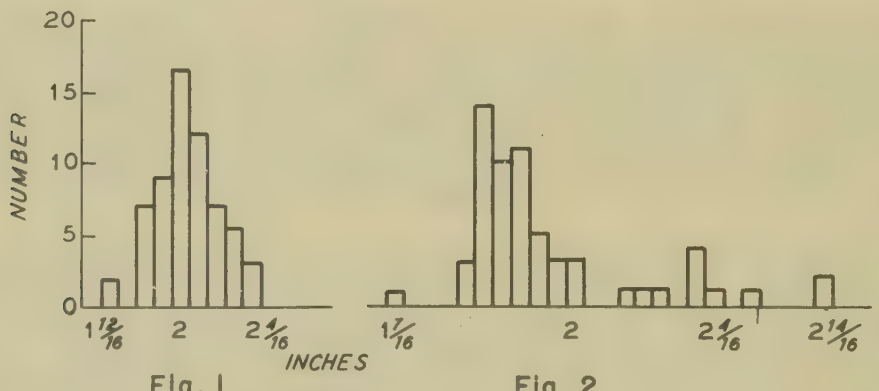


Fig. 1 Fig. 2

If growth is uniform the grouping of fish lengths around a mean should be bellshaped or compact such as figure 1 (Pond 1). If growth is not uniform, the grouping will be more expanded as in figure 2 (Pond 8). Remember, I explained that the fingerlings in Pond 8 ranged from 1 1/2 to 4 1/8 inches when the pond was drained shortly after these measurements were made.

Every fish-culturist should make these measurements at the end of the first month. These ponds showing an expanded curve or a curve not typically compact should be marked for immediate draining. The closer the grouping in the curve the more successful will be the output and the more nearly maximum the production.

THE VALUE OF VEGETATION

The presence of vegetation may have an effect upon production. If the water is clear, it is absolutely essential to have vegetation in the pond to protect the fingerlings from themselves. If a bloom can be obtained on a pond it is not necessary to have vegetation but the fish will only reach a limited size.

After that they will become emaciated, gaunt looking, and will not grow or stand the handling that they otherwise would. If there is an abundance of vegetation in the pond it is not necessary to have water bloom.

This year four of our ponds were perfectly clear with vegetation in abundance and four had a bloom with little or no vegetation. In the ponds with vegetation, the last one was drained after a period of 138 days. The fish continued to grow to 3 1/4 inches in length and the pond produced 12,409 fingerlings or a total of 176.26 pounds per acre.

In the ponds without vegetation, although there was an abundance of forage food, the fish, with certain exceptions, did not grow after two to three months. In two high-producing ponds they measured 2 5/8 inches and 3 1/8 inches after six and seven months time, but the fingerlings had not grown for four and five months, respectively. They weighed considerably less than the average fish of this size. It seems a waste of time to hold bass four or five months after they have stopped growing. Those ponds could be producing a second crop, but the point I wish to emphasize is that the fish ceased to grow.

Contrast this with growth in Pond 5. A bloom was maintained until the last of August. The bass had not grown in this pond from June 12 at which time they had reached 2 5/8 inches in length. Fertilization was stopped the latter part of August and the bloom cleared up almost immediately. Some vegetation had started, but when the bloom disappeared it began to flourish. On September 5 (about one month later) the fish had reached a length of 3 3/8 inches after a stationary period of three months. Compare this eight month growth period with similar growth in Pond 2 where the fingerlings reached 3 1/4 inches in 138 days.

Counting fingerling bass by hand. Lack of holding tanks necessitates use of the overflow from the breeding lake where tubs of fish, covered with bobbinette, are sunk overnight.

It is true that vegetation is a nuisance in that it requires a considerable amount of raking and stacking before the fish are removed. It can be killed with sodium arsenite weed killer a short time before the pond is drained, leaving a thin black muck on the bottom. I have also used weed killer with a considerable degree of success to control the height of the vegetation, by letting the growth attain the desired height and using one or two light treatments during the season to keep it there without killing the vegetation off. Either method of handling vegetation requires experimentation in each separate water.

There are two factors this year that may have affected growth in our ponds without vegetation and with water bloom. First, there is competition for the same food within the pond by the forage fishes used. Secondly, there is a lack of substratum for insect larvae which are the food of the larger fingerlings. On the other hand, the large number of forage fish used to stock these ponds should insure a bountiful supply of food. There is evidence of bream spawning up to the time the ponds were drained.

Certain vegetation is less desirable because it is a nuisance. These include Naias, Utricularia, Ceratophyllum and Anacharis. These species become impenetrable masses in southern waters. Potamogeton americanus or other species of Potamogeton with floating leaves are more desirable since they leave open water underneath.

THE USE OF FORAGE FISH

The value of forage fish is a much debated question. It is generally thought that they are beneficial. My own opinion at present is that the ecology of the bass pond has not been worked out thoroughly enough and that previous authors have reached their conclusions concerning the value of forage fish where all of the conditions in the pond were not uniform. There might have been differences in other foods, lack ofuniformity of fry stocked and other facts which have been enumerated in the previous paragraphs. The ecology and food relationships need to be worked out for each species of fish in a pond separately and then combined with other species or with bass to determine the exact effect on the pond and the best way of handling the various species.

I am not ready to commit myself on the question of the food value of the bluegill bream[1] or other forage fish, but I shall try to show the inadequacy of forage fish as they are now handled. Preliminary experiments at Marion, Alabama, in 1936, and at Welaka this season have yielded startling results. They have indicated that the number of bluegills and other fish used per acre were not enough to supply the bass fingerlings through the season and that the ecology of the ponds is not worked out well enough to use them intelligently. Let us discuss the problem very briefly.

At Marion, Alabama, the ponds were stocked with bass fingerlings according to regular hatchery procedure--not as they were here this year--so the production of fingerlings is only of incidental interest. One pond was stocked with 75 bream per acre, two ponds with 100 per acre, one with 110, another with 115, and a sixth with 174 brood bream per acre. Only one pond yielded any bream. It produced 2,150 but it only produced 622 bass fingerlings. The other ponds produced from 5,500 to 14,800 bass per acre with no bream.

This year four ponds were stocked with bluegill and shellcracker sunfish mixed. Ponds 5 and 6 were stocked at the rate of 300 sunfish per acre, and ponds 7 and 8 with 400 per acre. In addition,500 golden shiners per acre were used in ponds 6 and 7. These shiners ranged from 7 to 14 inches in length. The eggs counted per female varied from 12,000 in a 7 inch individual to 50,000 in a 13 inch female. These ponds were fertilized with cottonseed meal for periods ranging from 15 to 24 weeks, using from 750 to 1,200 pounds of meal per acre. One

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[1]The names "bream" and "sunfish" are used interchangeably throughout the text since sunfish, especially bluegills, are known as bream in the South.

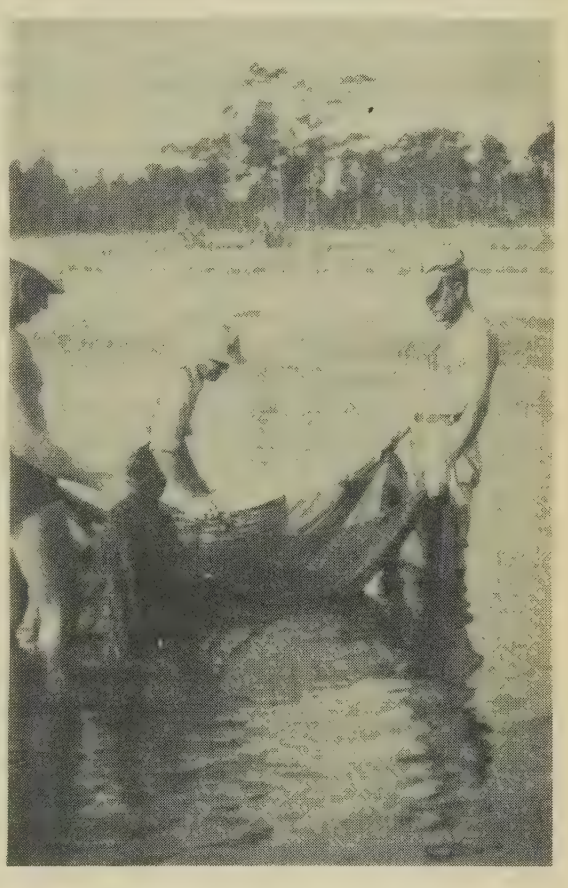
can see the food should have been well taken care of. Three ponds were stocked with 20,000 fry per acre; the fourth with 15,000.

All of these ponds lacked vegetation for the simple reason that so much meal was used that there was a continuous water bloom over the season. According to Swingle's experiments on bream, this should be ideal for their propagation. The sunfish spawned from the time they were put in there until the time the last pond was drained in October. Very small fingerlings were taken each month when the bass were measured.

The bottom food was about one-third lower than in other experimental ponds, but due to the water bloom, the organic content in the plankton was at least twice as high. I shall discuss elsewhere the effect of forage fishes on the bottom food and its makeup, but if bloom is beneficial the ponds were in good condition.

Pond 7 was drained on September 13 and yielded 10,148 fingerlings per acre or a survival of 50.7 per cent. These fish were 3 1/8 inches in length. The total number of pounds of bass was 108.3 per acre, which is about average for ponds in which fertilizer is used alone. The peculiar part is that only 44 young bream and 144 fingerling golden shiners were taken from the pond. There were 14 select bass from 11 to 14 inches in length.

In pond 6 drained October 4 there were returned 8,328 fingerlings per acre for a survival of 41.6 per cent of which six were selects. The fish measured 2 5/8 inches in length and the total weight per acre was 64.87 pounds. Of the forage fish only 38 small bream were recovered and 2,562 small shiners per acre. My notes show that the shiners spawned before the pond was stocked with bass so that the large number recovered, as compared with the other ponds, is undoubtedly due to that condition. There was evidence of spawning among the bream up to the time the pond was drained.



Removing fingerlings from pond No. 6. This pond is difficult to drain because the bottom is at sea level.

Water bloom was maintained in pond 5 until after fertilization stopped in August. The bass in this pond reached 2 9/16 inches on May 6 and remained about this length until August 8 when they reached 2 13/16 inches. As soon as the fertilization was terminated, the water bloom disappeared and some vegetation began to grow in the pond. By September 8 the fish had reached 3 3/8 inches. The growth was undoubtedly due to cannibalism because there was no difficulty in securing

a sample for measurements up until August 8. On September 8 it was necessary to seine completely around the pond in order to get an adequate sample.

The bream which could be taken in the samples were those spawned previous to the time the pond was stocked. By July 14 they had reached 3 3/16 inches in length. There was evidence that they were spawning all during this period because a few fry were always taken in the sample. No bream of in-between sizes were ever recorded. After the water bloom in the pond cleared up, and apparently the number of predator bass was reduced, the spawning activities began to produce in-between sizes of bream in considerable numbers.

When the pond was drained on October 26, a total of 838 bass per acre, averaging 7 5/16 inches in length and ranging from 4 to 16 inches, were removed. This is a survival of 4.2 per cent. A total of 4,399 bream per acre were removed, measuring between 1/2 and 5 inches, in addition to 1,127 fingerling shiners.

Table 2. Production in Ponds with Forage Food

Pond	Stocking Rate Bass	Bass Production per acre			Survival per cent	Fingerling bream	Forage Shiners
		Fingerlings	Selects	Pounds			
7	20,000	10,148	14	108.3	50.7	44	144
8	15,000	2,108	54	56.55	7.7	99	*9,800
6	20,000	8,328	14	64.87	41.6	39	**5,686
5	20,000	838	14	- -	4.2	4,399	2,532

*Fingerling shad **Spawned before pond was stocked

It is worth while to note that although the pond was adequately stocked with adult brood bream which spawned continuously throughout the seven month season up to the time the pond was drained, the yield of bass was very small. It is also important to note that during the first part of the season when the pond was adequately stocked with bass there was very little growth after the second month. No fingerling bream aside from very small fry were taken in the samples except those spawned before the pond was stocked. In other words, in this pond and in the others stocked with forage fish the results were as unpredictable as they have been previously in ponds which were only fertilized. Therefore, there are ecological factors which prevent us from deriving certain yields in ponds with forage fish until more knowledge is available. It certainly emphasizes the fallacy of trying to produce two crops concurrently, or of holding the fingerlings for protracted periods.

The results from these four ponds serve to illustrate a number of things. Although they were stocked a little heavy with bass fry, in other ways our best knowledge was used in handling them. It, therefore, seems that we lack sufficient information for handling ponds with forage fish. The results seem to be unpredictable as indicated by a variation in the yield of fingerling bass. It is also indicated by the fact that these are the only ponds yielding so-called select bass.

Secondly, the yield of fingerling forage fish was very small. In pond 5 it was definitely illustrated that the only survival among the bream was in those spawned before the bass fry were transferred to the pond or after the fingerling bass were reduced in number. The same is true of pond 6. It seems from this and the experience at Marion, Alabama, that in all previous experimental work by other authors such might have been the case, although it had not been detected.

Thirdly, the yield of bass in pounds per acre was less than in ponds where only fertilizer was used. The fish were so thin where the production was higher that even the men on the station noticed the difference.

Table 3. Representative Growth Rates of Largemouth Bass in Ponds.

Pond	First Month	Intermediate as stated	Second Month	Third Month	Fourth Month	Fifth Month	Sixth Month	Seventh Month
1	2	2 7/16* (50 da.)	-	-	-	-	-	-
1	2 2/16	2 10/16* (54 da.)	-	-	-	-	-	-
2	1 14/16	-	2 7/16	3 5/16	3 4/16*	-	-	-
3	1 15/16	-	2 8/16	2 11/16	2 12/16* (113 da.)			
4	2	-	2 9/16* (62 da.)	-	-	-	-	-
8	2 7/16	2 6/16* (42 da.)	-	-	-	-	-	-
5	1 12/16 (25 da.)	-	2 9/16	2 10/16	2 12/16	2 13/16	3 6/16*	-
6	1 12/16 (25 da.)	-	2 6/16	2 10/16	2 9/16	2 9/16	2 9/16	2 10/16*
7	1 11/16 (24 da.)	-	2 8/16	2 14/16	3	2 15/16	3 2/16*	-
8	1 13/16	-	2 7/16	2 8/16	2 10/16*	-	-	-

*Date drained.

In order to utilize space to the fullest extent the procedure for handling ponds as recommended from these illustrations would be somewhat as follows. All ponds should be stocked with bass fry to be grown to about 2 1/2 inches in length. This may be done in from one and one-half to two months where food is sufficient . The ponds which show a variation in size range of the fingerlings at the end of a month should be drained immediately.

Table 3 shows growth rates in the various ponds at Welaka this year. Ponds 1, 2 and 3 were fertilized; ponds 5, 6 and 7 contained forage fish in addition to fertilizer. These growth rates are about the same as in all previous experimental ponds. The months are only approximate because the date of stocking does not necessarily coincide with the sampling time in monthly intervals. The point

brought out in table 3 and figure 3 is that there is relatively little growth after approximately the second month. It is, therefore, most economical, from a production standpoint, to drain the ponds at this point. It emphasizes the element of time as a factor of importance. Further experimental work may yield information that may help in overcoming this cessation of growth.

When growth ceases the ponds should be drained. Each should then be stocked with adult bream and allowed to go until the end of the season. All ponds at Welaka handled in this way are well stocked and the sunfish are of large size. One pond has produced two crops of bass this season averaging 2 7/16 and 2 5/8 inches in length. In August it was restocked with sunfish brood stock and from all indications will produce a good crop of fingerling bluegills. These fingerling bluegills are at present (October) about 2 1/2 inches in length. The ponds are being fertilized just as one would for the production of bass.

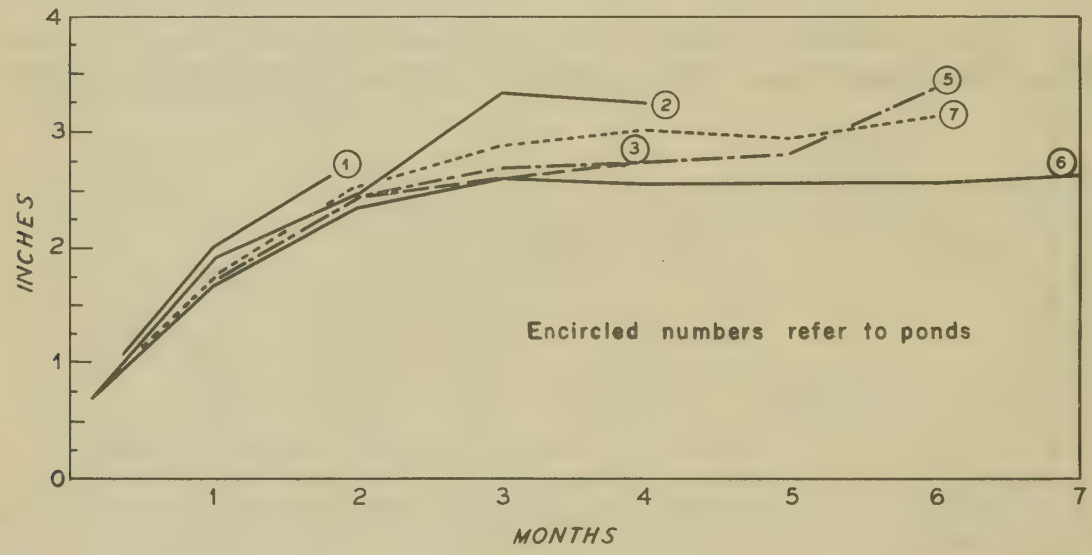


Figure 3. Growth of fingerling bass in ponds at Welaka, Florida, 1939. Figures in circles refer to pond numbers from table 3.

I think that ponds handled in such a fashion will give a maximum yield. There will be less variation in the size of bass fingerlings, and consequently less likelihood of erratic production. It will mean that fish-cultural methods will have to be intensified, and the burden of work increased, but the results justify the means. We have been draining the eight ponds on the experimental unit steadily since April and will not complete the work until about the first of January. Two ponds have produced two crops of bass, and four others one crop of bass and one of sunfish. At such a time as our knowledge enables us to use forage fish, we may change the methods accordingly.

COST OF PRODUCTION

Let us discuss the cost of production from a practical point of view. Our hatchery here has been divided into two units, one operated along conventional

fish-cultural lines and the other experimentally. To insure comparative data on the two, no advice was given to the fish-cultural unit aside from the fact that it is desirable to use cottonseed meal. Therefore, all work at the latter unit was done according to fish-cultural methods as ordinarily practiced. There was a shift in the fertilizer from the sheep manure and superphosphate used last year to cottonseed meal this year. In all about 100 pounds of fertilizer was used per acre on this unit.

On the experimental unit all the practice was as outlined above. The production averaged 11,655 fingerling bass per acre in five ponds handled in this way. On the other unit where ordinary precautions were taken the average was 5,034 fingerlings per acre, a large percentage of which averaged less than two inches in length. None on the experimental unit was less than about 2 1/2 inches. The highest survival on the fish-cultural unit was 43.2 per cent in a pond which produced fingerlings measuring 1 13/16 inches. This is a pretty fair survival. The average survival on the experimental unit was 78.72 per cent.

We will assume that the cost of labor per acre is the same, that is, from the hatchery upkeep standpoint, because a regular crew is maintained at all times. Of course, more time was spent draining the experimental unit because of the intensified use of the ponds. Therefore, the cost of any outside labor would be for the additional time spent in draining. The additional cost of fertilizer per acre was for 200 pounds of cottonseed meal which sells for approximately $1.75 a hundredweight, or $3.50 per acre on which 6,621 more fish were produced. This is equal to 53¢ per thousand fish.

In addition, these same ponds on the experimental unit will produce a crop of fingerling bream. The ponds will not be drained until later, but indications are that they are adequately stocked. The cost of fertilizer, aside from the cost of draining will be $5.25 for a second crop of fish.

I think that this is quite reasonable compared with the cost of buying fish, and will increase our hatchery production at least three or four times the present yield. There is no doubt that the procedure can be followed at least as far north as the most northern tier of states. Success at most hatcheries may not be immediate. At Natchitoches it took three years to build up the fertility of the ponds to the point where the select bass were practically eliminated.

The study of methods has just begun. There is much to be learned about the ecology of the bass. Each fish-culturist may find some variation in handling and stocking that might help. Other fertilizers may be used in sections of the country where they are cheap with just as good results as cottonseed meal here. In more northern sections it may be found that the digestion of meal in the pond is not rapid enough to give good results in a short season. In such a case mineral nitrates must be added to stimulate the digestion of carbohydrate materials. There may be certain elements lacking in some soils which will have to be added to the fertilizer used. However, I am confident that the method outlined will operate to advantage.

A CLOSED WATER SYSTEM FOR A HATCHERY

By G. Clifford Carl
Cowichan Lake Hatchery, Lake Cowichan, B.C.
Fisheries Research Board of Canada

DURING THE SEASON of 1938 the Cowichan Lake Hatchery experienced a series of epidemics of diseases including furunculosis and ichtyophthiriasis, an account of which appeared in the May - June 1939 issue of the PROGRESSIVE FISH-CULTURIST. Since this was the first season in which these diseases were known to occur at this hatchery and since it was also the first season during which Cowichan River water was used to augment the regular creek gravity supply which is insufficient during the summer, the new water supply was naturally suspected as being the source of infection.

Two methods of preventing the recurrence of these diseases seemed to be possible; first, disinfection of the river water by chemical or electrical means and second, elimination of the river water as a source of supply by adopting a closed water system using water only from the original and uncontaminated supply. The first method was rejected as being too costly in installation and the alternative course was adopted.

The following account is a description of the revised water system with particular reference to the construction and operation of the filter. It is given in the hope that the information may be of use to others who contemplate similar changes in a hatchery supply.

In the development of a closed system for this hatchery three major structures were essential, namely, a reservoir, a filter and a pumping system. A reservoir was necessary to take care of fluctuations in volume and to allow for the settling of debris. Further, by making possible a constant addition of cooler creek water, the temperature was maintained at a lower level than would otherwise have been possible. The filter was considered indispensable for the removal of parasites and disease organisms. Since a pumping system was already installed at the hatchery only minor changes in pipe connections were necessary after the construction of the reservoir and filter in order to convert the old system to one of the closed type. Accordingly, construction was carried out in the spring of 1939 and the new system was employed during the ensuing dry summer season.

The arrangement of the units is as follows. A reservoir receives all the water from the hatchery building and from a battery of 12 ponds connected in six double series. From here the water is lifted by a rotary pump operated by a small diesel engine to the filter tank where after passing through the filtering medium it is redistributed to the hatchery and ponds. The total volume of water enclosed by the system is about 70,000 Imperial gallons and the rate of circulation by pump alone is about 180 Imperial gallons per minute which results in one complete turnover in about 6 hours. In addition, however, the system receives a constant

flow of fresh water from the regular gravity supply at the rate of about 60 gallons per minute which produces a change of water every 20 hours. The inflow of water takes care of losses by leakage and evaporation and also tends to prevent wide variations in temperature. The experiment has apparently proved to be entirely successful since no diseases or parasites have appeared during the course of the summer and water temperatures have remained much lower than in the previous season, when river water was used.

RESERVOIR

The reservoir at this establishment consists of a wooden tank measuring 20' by 20' by 5' deep situated below the hatchery outfall and near the pump inlet pipe line. The overflow from the ponds was diverted into the tank and the pumping system was connected by inserting a T and short sideline with foot valve in

Arrangement of outdoor ponds; reservoir in middle background, pump-house at left.

the main supply line. Fine-meshed wire screens placed in the inlet to the reservoir collect a portion of the debris normally present in the hatchery overflow. A system of baffle boards aids the settling process by eliminating all swirling action in the tank. A central stand-pipe acts as an overflow and may be removed to drain the tank for cleaning.

FILTER

The type of sand filter usually employed in the purification of water supplies consists of a tank containing gravel supporting a layer of sand as the filtering medium. A system of pipes beneath the gravel collects the filtered water

and leads it to the distributing main. The size of the tank depends upon the amount of water to be filtered since the delivery of the filter is proportionate to the area of the filtering surface. The shape is a matter of choice. In general, a rectangular tank is more satisfactory than a circular one since it lends itself better to the installation of the collecting pipes.

Construction: The filter tank installed at this hatchery measures 10' by 15' by 7' inside dimensions, giving a filtering surface of 150 square feet. The sides and bottom are of 2" by 12" fir planks placed lengthwise and supported by 6" by 5" posts and yokes placed at 2 foot centers, the yokes being dapped for the posts. The ends are of 3 1/2" net by 12" planks placed vertically and held in position at the bottom by a 4" by 6" timber bolted to the floor planks and at the top by a frame of 6" by 10" timbers held together by tie rods. The whole structure is supported several feet above the ground level by two 8" by 14" caps on eight posts resting on concrete blocks. Extra heavy material was used through-

General view of the completed filter.

out in the construction of the tank and stand since the weight of the gravel, sand and water was calculated to be about 50 tons. The major features of the construction may be seen in the accompanying photograph of the completed structure.

The water-collecting system in the bottom of the tank consists of 50 galvanized iron pipes of 1 1/4" inside diameter, each provided with 15 holes 1/4" diameter, staggered in two rows along the under side. The pipes are connected to a central 6" wooden main, 25 on each side and approximately 6" apart. The ends of the collecting pipes are plugged to prevent the entrance of gravel. The arrangement of pipes and main may be seen in the illustration.

About 8 cubic yards each of gravel and sand were used as the filtering medium giving a 3-foot layer on the bottom of the tank. Since it was impractical to purchase the gravel and sand graded as to size, ungraded material was hauled from a nearby stream bed and sorted by hand. By using wire screens of suitable mesh size, three lots each of gravel and sand of different degrees of coarseness were obtained. The gravel ranged in size from stones 3 or 4" in diameter to pebbles about ¼" in diameter while the sand varied from coarse to fine, the average size of the particles of the finest grade being about 0.5 mm. Since the filtering process is carried out by the finest grade of sand it is important that the material in this layer be of the proper size and shape. Too fine a grade of sand will tend to clog while too coarse a grade will allow incomplete filtration. The most satisfactory type of sand is composed of sharp particles with an effective diameter between 0.4 and 0.6 mm. A 30-inch layer of sand of these specifications will permit the filtration of 1.2 to 1.6 Imperial gallons or 1½ to 2 U. S. gallons of water per minute per square foot of sand surface.

Since this type of filter is cleaned by reversing the flow of water the distributing main must be connected to a second water supply for backwashing. In the case of the filter at this hatchery the small gravity supply is used for this purpose. For carrying off the waste water during washing an outlet is provided on one side of the tank a foot or more above the sand level and leading to a sluiceway discharging outside the hatchery system. One or more gutters may be included inside the tank to facilitate the run-off of the dirty water. Unless an automatic valve is installed to control the level of water during filtration an overflow must be included just below the rim of the tank to take care of surplus water.

Operation: In operation the maximum output of the filter is obtained when the water level is maintained at its highest point. However, since the rate of filtration varies with the amount of accumulating silt clogging the sand, the level of the water seldom remains constant unless controlled by an automatic valve on the inflow pipe and hence the depth of water must be regulated by adjusting either inflow or outflow valves by hand. It will be found, for example, that after a period of operation the flow will be reduced so that the level of the water in the filter will rise unless regulated by adjusting the valves. This decrease in the rate of flow is due to the accumulation of dirt on the filtering surface, and also to the settling and packing of the sand under the pressure of the overlying water.

When the delivery of the filter falls below the demand, the original rate is restored by back washing. To do this, the water level in the filter tank is lowered by shutting off the inflow and allowing the water in the tank to flow out by way of the delivery system or by way of the discharge. The delivery line

is then closed and the auxiliary water is turned into the collecting system forcing a flow of water up through the sand carrying with it the accumulated dirt. At the same time the gravel and sand tends to be resorted since particles which have settled downward are forced back into place by the buoyant effect of the water. If it is found that the reversed flow of water is insufficient to cause a boiling action through the sand to remove all the silt, it may be necessary to agitate the sand surface with a broom or rake during the washing. If compressed air is available, a supply introduced during the back washing will increase the flushing action of the water. As soon as the waste water appears reasonably clear the discharge vent is closed, the auxiliary water supply is shut off, the inflow is turned on and the filter is ready for service once more. In the case of a filter of the size described, the flushing operation requires about 20 or 30 minutes and from 1200 to 1500 gallons of water.

Delivery: The output of a rapid sand filter operated by gravity depends upon the size and character of the sand grains composing the filtering element and upon the depth of water overlying the sand bed. However, since the depth of most filters is limited to a few feet, the main factor is the type of sand used. In the present case the sand was gathered from the bed of a small stream and consequently it contains much material of a smaller size than usually specified. The result is that the volume of water filtered varies from 195 Imperial gallons per minute immediately after flushing to 90 gallons per minute after the sand has accumulated suspended material resulting from pond cleaning operations. The average production is 170 to 180 Imperial gallons per minute or about 1.2 gallons per minute per square foot of sand surface.

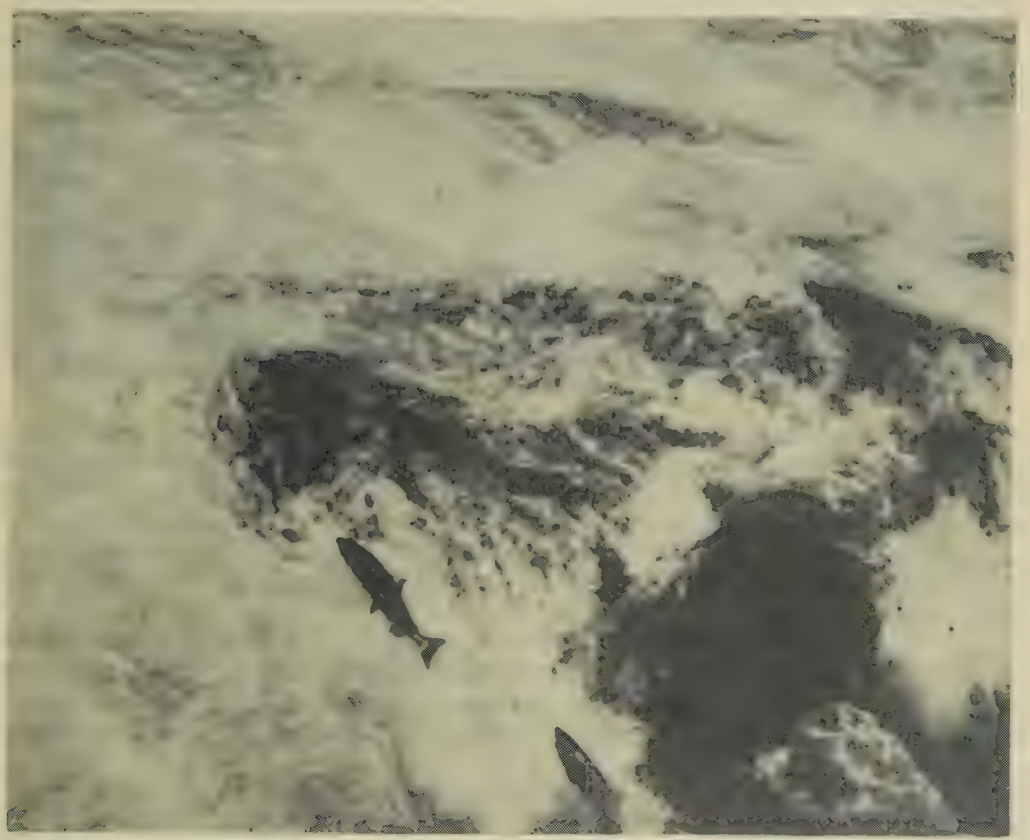
Efficiency: The efficiency of the filter in the removal of bacteria has not yet been determined but it is hoped that a thorough test may be made during the height of operations next summer.

Cost: The cost of construction is usually an important factor and may determine what course to adopt when two or more possibilities are considered. Although the cost of materials and labor varies with the locality the approximate figures for these items in the construction of the filter are given here for comparison: Lumber (including hauling) $78.00; pipes and valves, $176.00; hardware, $52.00; sand and gravel (including labor of screening), $66.00; labor (carpenter and helper), $74.00; total $446.00.

TRANSPLANTING THE COLUMBIA'S SALMON

Salvaging the Salmon Runs Obstructed by the Grand Coulee Dam

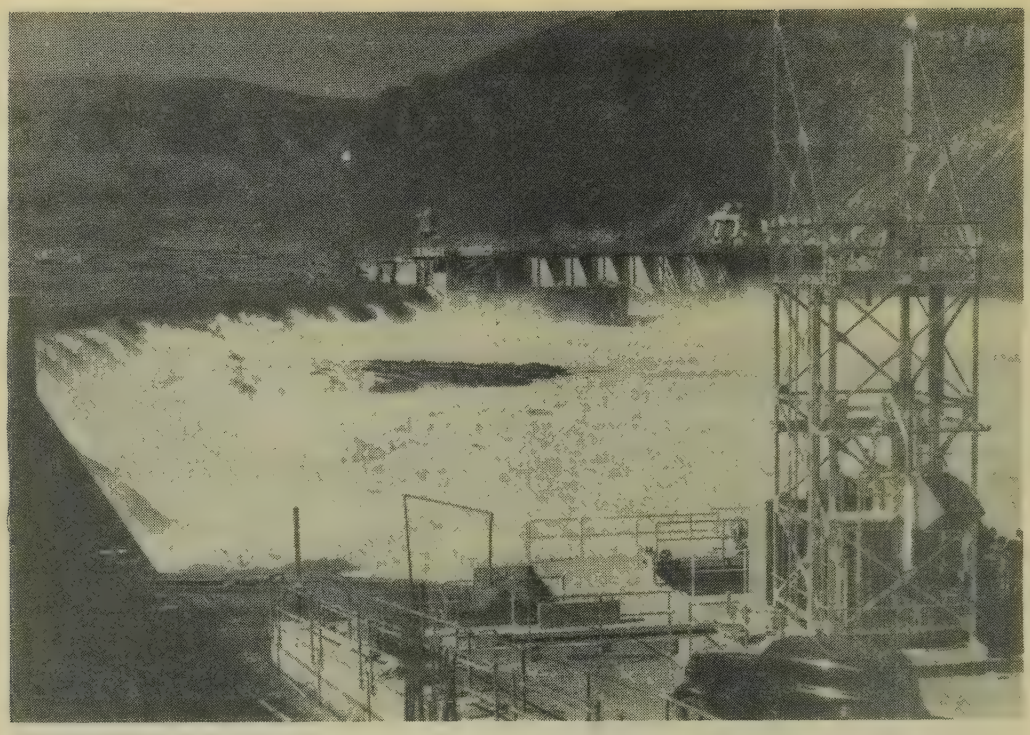
THOUSANDS OF Columbia River salmon travelled overland for miles in specially constructed air-conditioned taxis this fall to insure successful completion of the largest fish-transplanting task ever undertaken in the United States, Secretary of the Interior Harold L. Ickes today was advised by Acting Commissioner



Salmon jumping in eddies at the base of the Rock Island Dam. Finding one of the three fish ladders, however, delays the migration but little.

Charles E. Jackson, of the Bureau of Fisheries. The aquatic hitchhikers were furnished transportation when it was revealed that the massive Grand Coulee Dam in Washington State would prevent them from moving in seasonal "runs" to old spawning grounds and would necessitate their removal to new homes.

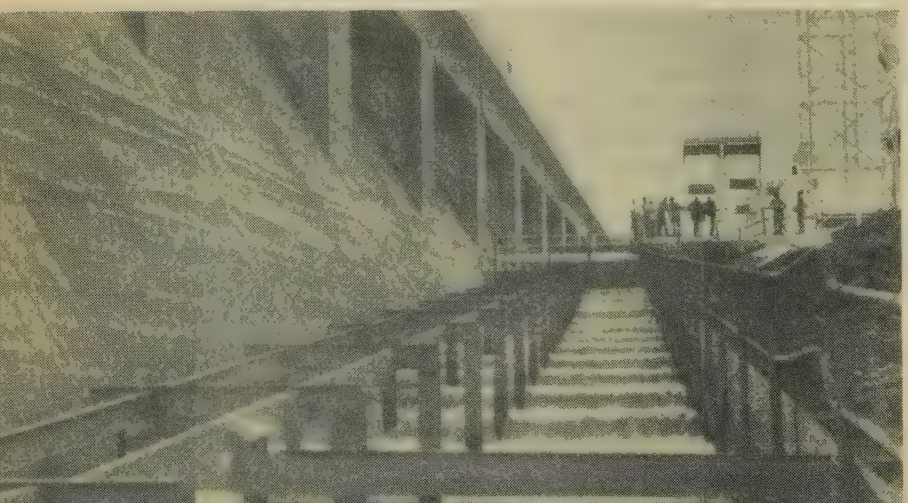
Four years hence, when the progeny of this year's run mature and again seek the spawning grounds, it is expected that the fish will be guided by instinct to the tributaries to which their parents were transplanted.



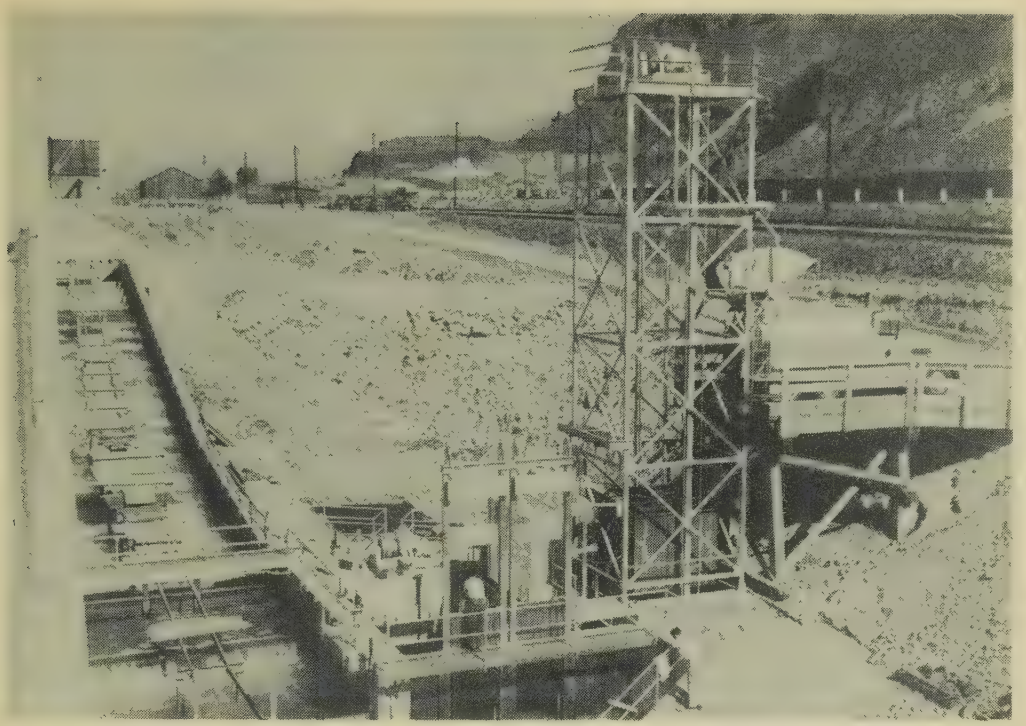
The successful outcome of the Coulee transplanting venture, scientists declare, may produce far-reaching effects upon the salmon fishing industry in other sections of the country. Not only will the detailed records of the experiment afford much valuable information concerning the problem of transplanting salmon runs to tributaries other than those to which the fish are native, but also reveal many hitherto undiscovered facts relating to the biology of salmon and steelhead trout.

Meantime, with approximately 50,000 fish moved - some of them a distance of more than 150 miles - the Bureau of Fisheries operations in the Columbia River region this year constitutes an unusual feature of activities under the National conservation program.

Foundation of the work was laid in surveys which showed that it would be impossible to pass the runs of fish beyond the completed dam through fishways such as have been successfully employed at the dam at Bonneville. The great height



Above: Rock Island Dam from west shore. Fish elevator left foreground; 2nd elevator at center fish ladder, 3rd elevator and ladder hidden from view at far end of dam.
Left: Fish ladder at east end of dam. Upward migrating salmon are diverted by barrier into collecting pool where men are standing, then into elevator (right).



of Grand Coulee and the turbulence of the water expected below it made it appear impossible to get the adult upstream migrants over the dam or the young downstream migrants back without heavy mortality.

As a consequence, it was decided instead to trap the adults during their spawning migrations at Rock Island Dam, near Wenatchee, and transport them to a hatchery now being built near Leavenworth, on the Wenatchee River. There the eggs will be taken, fertilized and incubated to the "eyed stage" and then transported to sub-hatcheries along the Entiat, Methow, and Okanogen Rivers. After hatching, the fish would be planted in these streams, all of which enter the Columbia below Coulee Dam.

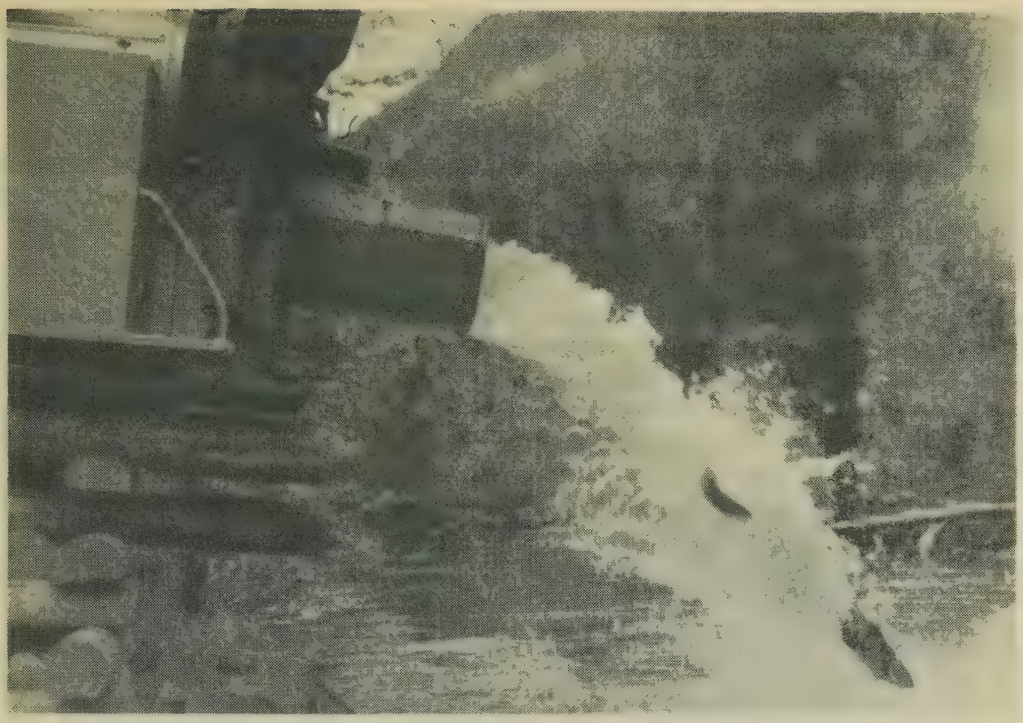
Rapid progress in Coulee Dam construction, however, and legal difficulties in obtaining title to sites brought about emergency conditions during the season of the 1939 run which the hatcheries were not equipped to meet, with the result that the unprecedentedly large fish-transplanting program was brought into play.

Above: Moving day for salmon. General view showing facilities for movement of fish from fish ladder (l.) through collecting pool and brailing chamber (center) to elevator and awaiting tank truck (r.).
Right: Fish entering elevator from brailing chamber so named because slatted floor can be tilted to force laggards to enter elevator cage.

Selection of waters where the fish would spawn naturally, rather than by the artificial hatchery method, was first undertaken, and arrangements made for placing the fish in the Wenatchee and Entiat Rivers, Nason Creek, and Wenatchee and Osoyoos Lakes, the latter two bodies of water being used for blueback salmon, since the young fish of these species must have a lake habitat to survive. Chinooks and steelheads were liberated in the streams. Weirs were constructed in the new quarters, to prevent the fish wandering back into the Columbia River, and exhaustive studies were made of the food supplies and the temperature and chemical characteristics of the water not only in the new areas, but in the Columbia and in the trucks used to haul the fish to their new homes.

During the entire season, eight specially built fish trucks were used in the transportation of the fish to the streams below Coulee Dam from the traps at Rock Island Dam. With the fish compartment of each truck holding 1,000 gallons of water, ice storage cooling systems kept the temperature of the water in which

Above: A new Pacific Fleet. Specially constructed tank trucks furnished taxi service to carry 50,000 salmon to their new spawning streams. (Reclamation photograph).
Left: Unloading salmon into a tributary of the Wenatchee River, to allow the fish to seed some of the best spawning grounds in central Washington.



the fish were hauled to nearly that of the stream in which they were planted, while pumps kept air and water in circulation.

The longest fish haul from Rock Island Dam was to Osoyoos Lake a distance of approximately 151 miles; the journey overland to Lake Wenatchee was 66 miles, Nason Creek, 65 miles, Wenatchee River, at Plain Washington, 50 miles, and to the Entiat River, 55 miles.

Trapping the fish at Rock Island Dam, approximately 14 miles down the Columbia River from Wenatchee, involved the use of ingenious methods to insure the safe transfer of the salmon from old waters to new. In each of three fish ladders in the dam, special compartments were set up by the Bureau of Reclamation, comprising a collecting pool, brail and an elevator, As the fish ascended the ladder, they were led into the collecting pool, where the lake-inhabiting species were separated from the river salmon by different sized pickets.

Above: Weir on ~~Nason~~ Creek prevents the fish planted above from wandering back to the Columbia River. Gates are provided to allow steelhead to return to the Columbia and the sea after spawning.
Right: The transplanting program is under scientific control. A biologist with his auto-laboratory makes chemical tests of water in trucks and streams.

Larger than the bluebacks, the chinooks were held back until the smaller fish had passed into the brail, and thence to the elevator. The brail, incidentally, is a grille-work device which tilts forward and eases the fish toward the elevator for their ride to the waiting truck.

When the fish entered the elevator bucket, they were enumerated by species, and, as soon as the required load was counted, it was hoisted to the truck platform, where the fish plus 500 gallons of water were discharged into the fish compartment of the truck containing an equal volume of water.

Not even the Dionne quintuplets were surrounded with more watchful care than the Columbia River fish in their moves to new homes, it is indicated in the reports. Complete and careful observations were made of the entire transplanting procedure, including the spawning of the fish after liberation, and men patrolled each stream constantly and covered the lakes by boats to watch the progress of migration.

Gold from the Columbia comes via the salmon. Here the biologist is studying the available food supply for fish in the tributaries.

As a result, it was found that mortality of the fish before spawning probably will be less than 5 per cent in all of the new locations, except in the Entiat River during the latter part of the summer, where fungus and what may be a bacterial infection may cause a somewhat greater loss of the late-planted fish before they have deposited their eggs. Before another season, however, research, now in progress, may find a way of preventing even this nominal loss.

(From a Department press release December 3, 1939. Photographs, except as noted by Zell Parkhurst, Bureau of Fisheries.)

EXPERIMENTS WITH FORAGE MINNOWS IN BASS PONDS

Eugene W. Surber and George E. Klak
U. S. Fisheries Experimental Station, Leetown, West Virginia

AS A RESULT of experiments principally with largemouth bass in nursery ponds at Fairport, Iowa, Davis and Wiebe (1930) concluded that the addition of adult forage minnows in ponds increased the production of fingerling bass. These experiments did not survey the maximum number of forage minnows which might be used in a pond. The purpose of this paper is to call the attention of readers of the PROGRESSIVE FISH CULTURIST to the fact that large numbers of forage minnows including those which are best suited theoretically to be non-competitors of bass, when stocked in numbers larger than the number suggested by Davis and Wiebe , (about 1,000 per acre) may decidedly interfere with the production of bass. The admonition of that old pioneer of bass culture, Dwight Lydell, against the use of minnows in brood ponds, undoubtedly has a solid foundation in experience. In the discussion of Birge's paper (Birge 1906, p. 157), the following remarks by Dwight Lydell are found -- "Something we never do is to introduce a live minnow in our bass ponds before or during the spawning season. I have known them to clean up a whole pond of fry by having them in there."

In the stocking of all ponds at Leetown during 1939, 10,000 smallmouth fry per acre were used. These were hand-counted. This number of fry is about half that suggested by Davis and Wiebe (1930) for maximum yields. It should be noted however that these workers had lower survival rates when 20,000 fry per acre were used than when 10,000 were used.

Cottonseed meal at the rate of 60 pounds per acre (average 480 pounds per acre per season) was added to all ponds in the new H series at intervals of ten days beginning April 15 and extending through August 14. Ponds C-1, C-5, and C-7 were fertilized beginning April 5 and ending July 7. An average total weight of 440 pounds per acre was added to the C ponds during the season.

The H series of ponds are long and narrow ranging in length from 220 to 540 feet and from 50 to 60 feet in width. The depths in their upper ends vary from fifteen inches to two feet or more, while their maximum depth at the kettle is about five feet. The C series are the feather-edge type of pond with clay puddled over marl bottoms. Their maximum depth is about five feet.

During the course of these experiments particular attention was paid to the prevalence of parasites. In ponds C-1 and C-7, there was evidence during late summer that strigeid worms were abundant enough to interfere with results (Neascus see sections E and F). In all other ponds, these worms were present, but were not sufficiently abundant to render the forage minnows sterile. Klak has observed that about 1,000 per fish must be present before the gonads are affected. During the summer of 1938 and again in 1939 Klak examined both black-head minnows and golden shiners taken from the same ponds. Although blackhead minnows contained

strigeid worms, golden shiners were unaffected. Davis and Wiebe (1930) found that blackheads were inferior to golden shiners as forage minnows in bass ponds. This was believed true, not because of greater predaciousness on the part of the blackhead, but because of their smaller size and the fact that they soon fell easy prey to the bass. Few were left when the ponds were drained at both Fairport, Iowa, and Leetown. The main reason why blackhead minnows were used in these experiments instead of golden shiners was because several charges that golden shiners consumed bass fry had already appeared in the PROGRESSIVE FISH-CULTURIST. Cooper (1935) performed some aquarium experiments in which golden shiners and blunt-nosed minnows consumed smallmouth fry 8 - 17 millimeters in length.

A. PONDS STOCKED WITH 6,000 OR MORE MINNOWS PER ACRE

Our experience with large numbers of forage minnows has been disastrous as evidenced by the results shown in table 1.

Table.1. Production of bass in ponds with 6,000 or more forage minnows per acre

Pond No.	Area	Year	Kind of Minnow	No. per acre	Date introduced	No. bass fry introduced	Date introduced	No. bass removed	Date	No. per acre	Per cent survival
C-5	2.6	1937	*Blackheads Blunt-nosed Golden shiners	57,692	Fall'36	13,000	5/17-5/21	370	8/12	142	2.85
C-6	2.86	1937	Blackheads	7,692	1/13/37	22,000	5/14-5/26	560	8/18 8/19	196	2.55
C-7	2.21	1937	Blackheads	6,787	Early spring 1937	20,000	5/14-5/26	670	9/2	303	3.35
H-11	0.65	1939	Blackheads	6,015	4/14/39	6,600	5/11	612	9/21	942	9.27

*1,500 adult minnows of each of the three species were placed in a pond where they were permitted to spawn throughout the summer. In the fall, all minnows in the pond, adults and progeny, were transferred to C-5 without an attempt to weigh or enumerate them. The total number of minnows was estimated to be about 150,000.

The average survival of plantings of bass fry in the presence of large numbers of minnows as illustrated by the figures above is only 4.5 per cent. The bass in C-5, C-6, and C-7 during 1937 attained an average length of 6.5 inches by mid-August. They were very uniform in size. Young forage minnows were present in all of these ponds when they were drained. In H-11, drained September 21, 1939, 612 bass or 9.27 per cent of the bass introduced (10,153) survived. These

averaged 106.04 millimeters (4.17 inches) in length (standard deviation 5.63 millimeters) and were the second largest bass produced by natural feeding during 1939. Only 876 of the 3,910 blackhead minnows survived the summer in H-11. However, it has been observed that blackhead minnows tend to hide away in the vegetation and remain behind in spite of the falling water when a pond containing bass is drained.

B. CONTROL LOTS. PONDS STOCKED WITH FEW OR NO FORAGE MINNOWS

The following figures have been compiled for comparison with results in section A.

Table 2. Production of bass in ponds with no or few forage minnows

Pond No.	Area	Year	Kind of Minnow	No. per acre	Date introduced	No. bass fry introduced	Date introduced	No. bass removed	Aver. lgth.	Date	No. per acre	Per cent survival
C-5	2.6	1939	None			26,718	5/10-5/11	9,823	2.93	8/9-8/10	3778	42.69
H-6	0.58	1939	None			5,936	5/11	2,367	3.32	9/7-9/25	4103	40.09
C-5	2.6	1936	Blunt-nosed	557	2/24 2/25	11,200	5/8 5/10	4,070	4-5	8/4-8/6	1565	36.34
C-6	2.86	1936	Blunt-nosed	339	1/28	9,000 s.m.* 19,500 l.m.	5/20	3,587 5,750		8/7-8/10	3265	29.49
C-7	2.21	1936	Black-head	618	1/28	29,800	5/9-5/10	6,649	4-5	8/16-8/19	3009	22.31

*Largemouth (l.m.) as well as smallmouth (s.m.) fry stocked in this pond.

The last three lots in the above table are not true controls, but the much better results attained with few or no minnows is significant. The 1936 results are included to demonstrate the probability that forage minnows, particularly when present in large numbers, consume smallmouth bass fry. The black fry of the smallmouth disappeared very rapidly when placed in ponds containing large numbers of forage minnows.

Specimens of bass were collected in nearly all ponds during 1939, to make certain that the disappearance of the fish could not be attributed to the presence of parasites.

C. PONDS STOCKED WITH 2,000 FORAGE MINNOWS PER ACRE

The use of as many as 2,000 forage minnows per acre in smallmouth ponds is unreliable as indicated in Table 3 below where an average survival of only 21.36 per cent of the bass fry introduced was attained. Although the bass in H-5 were large, no exceptionally large fish above the average were taken out. In other words, there were no "selects." Our observations indicate that cannibalism did not prevail in this pond since young forage minnows were observed as late as August 14. With young forage minnows present at that late date there was no need for cannibalism.

Table 3. Production of bass in ponds with 2,000 forage minnows per acre

Pond No.	Area	Year	Kind of Minnow	No. per acre	Date introduced	No. bass fry introduced	Date introduced	No. bass removed	Aver. lgth.	Date	No. per acre	Per cent survival
H-5	0.54	1939	Blackhead	2,000	4/12	5,670	5/11	185	5.37	9/8	343	3.27
H-7	0.58	1939	Blackhead	1,900	4/12	5,872*	5/19	4,256	2.91	9/8-9/26	7338	72.47
H-8	0.62	1939	Blackhead	1,987	4/12	6,268	5/10	1,810	3.57	9/18	2919	28.88
C-7	2.21	1939	Blackhead	2,000	6/5	26,442	5/10-5/11	8,441	3.04	8/22	3819	31.92

*Largemouth fry in H-7 only of this series.

Better results were obtained in pond H-8, where the blackheads apparently were not as much inclined to eat the bass fry introduced. Only four "select" bass were present in this pond.

Of particular interest are the results of the experiment with largemouth fry in H-7. The purpose of this experiment was to determine whether, because of their nearly transparent color and close resemblance to blackhead fry, largemouth fry had a better chance of survival than the black and conspicuous fry of the smallmouth. The comparison of the results between H-5 and H-7 strongly suggests that using 2,000 forage minnows per acre in a largemouth pond may bring far different results than the same number of forage minnows in a smallmouth pond.

D. PONDS STOCKED WITH 500 to 1,000 FORAGE MINNOWS PER ACRE

The figures in table 4 present the data from four smallmouth and one largemouth pond. Three of the four smallmouth ponds had an average survival rate of 43.30, while the four lots averaged 38.06 per cent. The controls (C-5, H-6) of 1939 without minnows had an average survival of 41.39 per cent. The average size of the bass in the control lots was somewhat higher, indicating no advantage in having forage minnows in a smallmouth pond.

Table 4. Production of bass in ponds with 500 to 1,000 forage minnows per acre

Pond No.	Area	Year	Kind of Minnow	No. per acre	Date intro-duced	No. bass fry intro-duced	Date intro-duced	No. bass re-moved	Aver. lgth.	Date	No. per acre	Per cent sur-vival
H-10	0.55	1939	Blackhead	1,000	4/13	6,600	5/10	3,347	2.82	9/20	6085	50.71
H-9	0.55	1939	Blackhead	1,002	4/12	5,695*	5/19	1,514	3.09	9/19	2753	26.58
C-5	2.60	1936	Blunt-nosed	557	2/24-2/25	11,200	5/8-5/10	4,070		8/4-8/6	1565	36.34
C-7	2.21	1936	Blackhead	618	1/28	29,800	5/9-5/10	6,649		8/16-8/19	3009	22.31
G-3	1.10	1939	Blunt-nosed	727	5/18	22,866	5/19-5/20	9,800	3.00	9/7-9/8	8909	42.86

*Largemouth bass

The experiment with 1,000 blackhead minnows per acre in a largemouth pond (H-9) was for comparison with H-10, a smallmouth pond. Cannibalism was noted in this pond at an early date. On August 14, bass 8 inches in length were seen swimming about in the pond. When the pond was drained September 19, thirty-eight cannibals weighing 8 pounds were removed. Among them were thirteen bass over 8 inches in length. The total weight of bass per acre removed from H-9 was 50 pounds.

In H-10 the total weight of smallmouth bass removed was 55.91 pounds. The cause of cannibalism in H-9 is unknown, but had it not occurred, it seems that the probable advantage of the transparent color of largemouth would have again asserted itself as it did in pond H-7 (see Table 3). An analysis of the results, although theoretical, lends support to this idea. In H-7 only ninety-three blackhead minnows of the 1,154 introduced were recovered when the pond was drained. In H-9 none was recovered when the pond was drained. About half as many (551) were placed in H-9 as in H-7 at the start of the experiments. Langlois (1935, p. 8) shows that 6.0 pounds of fish are required to produce a pound of bass. Using his figures and applying a correction factor for the bass consumed by the cannibal bass, the production of bass in this pond might have been 5,109 fingerlings 3.09 inches in length instead of 1,476 of that size actually removed. The 5,109 would then have represented a 89.71 per cent survival, which could be compared with the 50.71 per cent survival in its companion smallmouth experimental pond H-10.

E. INTRODUCTION OF YOUNG FINGERLINGS IN A POND CONTAINING LARGE NUMBERS OF FORAGE MINNOWS.

Pond C-1 (area 1.33 acre) was stocked with 7,980 (6,000 per acre) adult blackhead minnows weighing 43.65 pounds on April 13, 1939. To avoid having the minnows consume the smallmouth bass fry, the latter were held over in a separate pond until they were too large for the minnows to eat. On May 29-31, 13,300 of the young bass were introduced into C-1. At that time there was an abundance of blackhead fry in the pond.

During the summer, the large numbers of minnows present kept the pond roily and practically destitute of algae, although clumps of Potamogeton foliosus became fairly abundant. By the 19th of June, the average size of the smallmouth fingerlings was 56.55 millimeters. On June 21, four dead smallmouth fingerlings were found. This loss, and probably more not found, was attributed to the presence of the species of suctoria (protozoan gill parasite), described by Davis (1937) which were present in large numbers on most of the bass examined. No count of these parasites was made on June 19, but on July 10, it was estimated that each bass had 16,960 parasites per fish. As the season advanced the suctoria became less abundant. On July 26, only 4,002 parasites per bass were recorded, and on August 28, 3,632 suctoria per bass were present.

By June 22,the young bass had cleaned up all of the young minnow fry present. The spawning activity of the blackhead minnows had ceased also due to 100 per cent visceral infestation with the strigeid worms both encysted and unencysted described by Klak (1939, in press).

Five bottom samples were collected in this pond on June 23, to determine whether the pond should be drained at that time, but these samples averaged 0.32 gram (wet weight) per square foot of bottom including 102 chironomid larvae, 3.2 chironomid pupae, 44 Oligochaeta, 5.6 Ceratopogon larvae, 1.2 caddis larvae, 2.0 Berosus larvae, 3.0 damselfly nymphs and smaller numbers of other animals. Since the weight and number of animals was greater than in the adjacent brood stock pond C-4 (average wet weight 0.17 gram per square foot) the pond was permitted to stand until August 25 before it was drained.

Upon draining, 6,436 bass averaging 75.51 millimeters (2.97 inches) in length were removed. This represented a survival of 48.39 per cent, the second highest survival recorded in any pond. This lot of bass was the most variable in size of all experimental lots at the station, having a standard deviation of ±8.95 millimeters. One 12-inch "fingerling" was removed from the pond.

The method of utilizing forage minnows in this experiment apparently is better than in those experiments listed in table 1, but it was obvious that 6,000 forage minnows per acre were an excessive number for a pond. Half that number, or less, of golden shiners rather than blackhead should produce good results.

F. INTRODUCING FORAGE MINNOWS LATE IN THE SEASON

Pond C-7, area 2.21 acres, was stocked with 26,442 smallmouth fry on May 10 and 11, 1939. Four thousand four hundred (2,000 per acre) blackhead minnows weighing 23.56 pounds were held in spring water until June 5, before they were introduced into this pond. On June 21, males were found guarding eggs on stones placed in the pond for spawning. Young minnows never became abundant, and it is assumed that the young bass cleaned them up as fast as they were produced. During the latter part of the summer, minnow spawning fell off due to parasite infestation affecting the gonads of the minnows. When the pond was drained August 22, 8,441 bass averaging 77.24 millimeters (3.04 inches) in length were removed, giving a survival of 31.92 per cent. The bass fingerlings were uniform as indicated by a low standard deviation of ±4.83 millimeters, second lowest of all 1939 lots (lowest ±3.40 millimeters in H-7), a largemouth pond having the highest survival of 72.47 per cent.

CONCLUSIONS

1. Six thousand blackhead minnows per acre cannot be used successfully in ponds in which the black fry of the smallmouth bass are stocked.

2. Large numbers of forage minnows may be used if (a) the forage minnow adults are placed in the pond early, followed by stocking of bass fry or young fingerlings too large for them to eat, or (b) if the fry are stocked in ponds without forage minnows followed by stocking with large numbers of forage minnows after the fry became too large for them to prey upon. The first method appears best, but 6,000 per acre is an excessive number, and it is estimated that 1,500 to 3,000 per acre would be adequate.

3. The use of 500 to 1,000 forage minnows is not as harmful as 2,000 per acre, and slight advantage is noted in stocking 500 to 1,000 minnows per acre over stocking none at all.

4. Most of the experiments were conducted with smallmouth fry, but in two experiments where largemouth were used, results indicated that largemouth fry have a better chance of survival than smallmouth when placed with forage minnows.

5. At this station, all blackhead minnows when crowded are now infested with immature strigeid parasites that render this species sterile. Since the golden shiner is not affected by these parasites, and are probably no more carnivorous, a complete change-over to use of this species in future pond culture and experiments seems desirable.

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GENERAL MANAGEMENT SUGGESTIONS FOR LAKES SURVEYED IN 1937 IN THE SEVERAL NATIONAL FORESTS OF MICHIGAN[1]

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A FEW YEARS ago it would have been a relatively simple matter to prepare these suggestions; at present they are presented with considerable hesitation and with some doubt regarding their value. Fresh-water fisheries investigation has reached the point where it suggests that current practices in fish management are frequently of questionable value but has not yet gone far enough to indicate what changes and substitutions are desirable. The fish manager, consequently, is in a rather uncomfortable position.

Certain studies vital to fish management have been initiated in recent years, but most of these have not been on a broad enough scale or carried far enough to permit the drawing of general conclusions. A few are mentioned briefly to indicate the current trend of thought and to emphasize the complexity of the fish management problem.

The whole fish management problem may be presented in a very few words: An acre of water will produce only about so many pounds of fish. In the old days this poundage was adequate to supply the demand and fish conservation generally was not needed. Today, however, with increased population, more leisure time and highly developed means of transportation, the demand for fishing has very decidedly increased; in fact, it has increased to a point where the "supply" is inadequate. Ordinarily the problem could be settled very easily--if the demand for reasonably good fishing greatly exceeds the supply, increase the cost (license fees) to a point where the supply is adequate. However, in America the fish (and game) are the property of all of us, and the practices common to business cannot be applied here. Fishing costs must be kept low enough so all persons can enjoy the sport, even though the demand does greatly exceed the supply.

The fish conservationist must make the most of this situation and there is considerable question as to how far he can go in solving his major problem--that of supplying good fishing regardless of the demand. He has a few tools at his disposal but these are currently inadequate. He can:

1. Use the accepted fish management methods consisting of stocking, legislation, and environmental improvement.

2. Increase the amount of water by building more lakes. In Michigan, with some five thousand lakes, this method cannot be expected to be as important as in other states which have little water and which are engaged in extensive lake building programs.

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[1]Prepared for the Michigan Institute for Fisheries Research while the author was a member of the staff.

3. Restrict commercial fishing. Conservation has been defined as the greatest use of a resource by the greatest number of people. There is little doubt but that greater use by a greater number is obtained in sport fishing as compared with commercial fishing. Ordinarily it is believed that both types of fishing can be carried on in the same water without serious conflict. In fact, the removal of suckers, carp, etc., by commercial fishermen may actually benefit sport fishing. Commercial fishing may need to be curtailed in some instances, but this should not be done until scientific proof of the need is available.

4. Develop sportsmanship; sportsmanship in this case being interpreted as the catching of any number of fish the angler may be able to get, but the removal from the lake of only a few. This idea, advanced by Hazzard[1], is a very important one and is perhaps the most promising of the group if the angler can be con-

Jaw tagging legal-sized brown trout for spring planting in a controlled stream. Results proved ineffectiveness of such stocking where a large population of wild fish was present.

vinced that sportsmanship is perhaps the only alternative to ever increasing restrictions or ever poorer fishing.

A few problems which are of basic importance are listed below. As previously indicated, too little work has been done to demonstrate that they are proven facts. They should be regarded merely as possibilities.

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[1]Hazzard, A. S. 1935. Better fishing. Am. Wildlife, Nov.-Dec., p.89.

1. The poundage of fish in a lake probably remains relatively constant from year to year. Dr. David Thompson and associates in Illinois have found this to be true in a relatively large Illinois lake. If this condition is true generally, the chief problem of the fish manager will be to have as much of this poundage as possible represented by fish of the most desirable species and of suitable size. It is possible of course that the poundage can be increased by fertilizing or by introducing fish which do not compete for food with those already present, but the possibility of decidedly increasing the total poundage of fish on a large number of lakes seems rather remote at present.

Six Michigan lakes, studied in detail by the Institute, indicated a range in poundage from 24 pounds in one lake to 194 in another lake. Many of the lakes in the poorer portions of the state (State and National forests) will probably never support many pounds of fish.

2. It is probable that most lakes are at almost all times supporting their regular (maximum) poundage of fish. Thompson has expressed the opinion (orally) that when fish are removed, the "building up" of the poundage to the normal level requires only a short time.

The removal of some fish from the lake presumably leaves more food for the others and results in increase in rate of growth or in survival. Whether or not this building up is decidedly speeded up by stocking with fry or fingerlings in the numbers usually planted needs yet to be proven.

3. A study of fishing for four years on Fife Lake indicates that the total annual catch from a lake is relatively constant (above a certain minimum of fishing, of course). An increase of 92% in fishing (1936 over 1934) resulted in an increase of only 18% in the catch. It is possible that the finding in Fife Lake applies generally; that greater fishing intensity reduces the average catch per hour, not the total population of fish.

4. It is the writer's opinion that "fishing out" a lake to a point where inadequate brood stock remains is almost an impossibility. (Howe Lake near Grayling was found to contain 9½ legal-sized bass per acre after it was presumably fished out.) Winter kill during 1935-36 on two lakes in southern Michigan which are "heavily fished" yielded an estimate (based on actual counts along representative lengths of shore line) of some 1,100 game fish per acre averaging from 6 to 7 inches in length.

It appears too that there is ordinarily a certain balance between fish and food and that the usual decline in the catch after the first few weeks may be partially due to the removal of enough fish to temporarily change this balance, i.e., reduce competition for food and cause the fish to bite less freely. A lake may, perhaps, be temporarily "fished out" when only a relatively small percentage of the available fish has been removed; ie.,the catch per hour may decidedly decline. There is a possibility that a majority of our lake fish are never caught. This situation is perhaps more readily understood by using a comparison with farming: If a pasture is grazed to capacity by the cattle, you could probably soon

"catch" a cow with a handful of fresh grass. A continuation of this "fishing" would probably soon reduce the number of cattle to a point where there is less demand for food and the grass in the pasture would presumably increase. Long before the last cow could be removed by this method (if done in a large pasture over a period of time) the pasture would probably be so good that your handful of grass would go unnoticed and would fail to interest the cattle.

5. Over-population is undoubtedly a major problem in Michigan. Enough studies have been made to indicate the seriousness of this problem. Bluegills and perch are apparently the chief "offenders." (Some lakes in which bluegills required from 7 to 8 years to reach six inches have been stocked annually with small bluegills.) In the areas in which the Forests are located, intelligent manage-

Two way fish weir which settled an argument as to migration of fish from Houghton Lake and suggested proper management procedure to ensure good natural reproduction of northern pike.

ment will probably eventually be largely a matter of controlling the number of fish by balancing predator against pan fish, by limiting the number of fry produced through destruction of the nests or removal of some of the fry, or reduction of the population by some other means. It will probably be a matter of holding down the number of fish to a point where they will have enough food to reach a desirable size in reasonable time.

6. Stocking of fish in some Michigan lakes must be regarded as of questionable value in view of the several items mentioned above.

Game managers seem to recognize the futility of planting rabbits and most other game animals as a means of maintaining a supply. They recognize the need for reducing the population of deer where they are starving to death. When they do fish work in connection with game work, however, they apparently fail to fully appreciate that the problems are parallel with regard to stocking for maintenance. (These comments refer to stocking warm water lakes, not trout waters, although some of the same principles may apply there also.)

7. It need hardly be mentioned that the problems of fish managers will be primarily public relations problems for a considerable period of years. Most of the present findings of fishery biologists seem to discount accepted fish management methods--which have been over-sold to the fishing public just as the "buck law" has been over-sold to the hunter sportsman.

8. It has been found that fish may show good growth in very poor lakes . In Howe Lake this seemed due to the fact that young fish (bass and perch) were the primary food of the larger bass and perch and that the number was thereby kept reduced to a point where food was adequate for the remaining fish. Introduction of forage fish in such lakes might result in over-population of game fish because of the greater chances of survival of young game fish.

9. Until more is known about fish predators, they should probably be regarded as beneficial rather than injurious (in lakes). According to reports, several hundred gar were removed from a small lake in southern Michigan a few years ago. Now it is reported that in this lake catching a mess of bluegills of desirable size is becoming increasingly difficult. With over-population of pan fish a major problem, the desirability of having predators seems obvious. Pike and bass are, of course, preferable to gar and dogfish as predators of pan fish. Again there is a parallel with predator control in deer management.

10. Fish populations change much more rapidly than is generally supposed. In four years in Fife Lake some species of fish had declined decidedly in the catch while others had decidedly increased. A single examination of a lake gives no indication of the trend. Adequate management would require repeated examination. Suggestions made after one examination might be decidedly "out of date" and unsuitable within a very few years.

11. Certain age groups seem to predominate and the younger age groups are not necessarily the best represented. Some idea of the abundance of fish in the younger age groups would be needed to determine the desirability of stocking or encouraging the species. Methods for rapid and dependable sampling of fish in public waters are yet to be discovered.

More items might be listed, but the above mentioned points suggest why the specific suggestions (based on a hasty survey) for individual lakes are presented with considerable reluctance. A careful consideration of the general problems mentioned would probably prove more beneficial than a close scrutiny of the specific recommendations which might be made.

In the suggestions for individual lakes, stocking for maintenance of warm water species is generally not recommended. Since some planting is probably necessary at present because of public opinion, such planting might be based on the following suggestion.

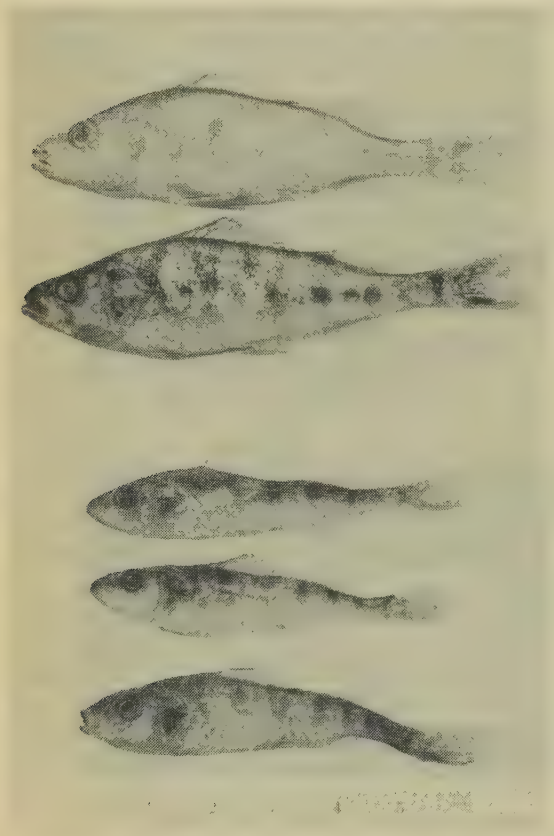
If the average size of pan fish caught is small, plant pisciverous fish (bass or walleyes). If the average size of pan fish caught is relatively large (suggesting though not proving fairly rapid growth), plant more pan fish (bluegills or perch).

A suggestion (not applicable to public lakes) made to the owner of a private lake might be briefly mentioned. An examination of the fish in the 35-acre lake indicated that bluegills, the dominant fish, were growing slowly; perch showed very good growth. The growth of bass could not be determined. Fishing was excellent in 1937. About 400 fish were taken at an average rate of over five per hour (the owner cooperating, with the Institute for Fisheries Research, kept a complete creel census).

Poisoning a lake over-run with goldfish planted in order that these fish (formerly produced in limited numbers as an attraction at certain hatcheries) might not be "wasted." The lake once yielded good catches of bluegills and is now stocked again with this species.

It was recommended that fish removal in 1938 be concentrated on bluegills and that at least a thousand be removed. If, after 1938, the bluegills showed considerable increase in growth (suggesting a marked decrease in number), the fishing for bass (removal of bass) should be increased the following year. Few forage fish were present and young bluegills were probably a chief food item of the bass. The suggestions were made in the belief that the continuance of good fishing in this moderately infertile lake was dependent on keeping a balance between predator and prey and that this could be influenced by moderately intensive fishing for (removal of) either predator or prey.

An important item to the fish manager is the knowledge of the rate of growth of the fish. The scales collected in the forests have not yet been checked for growth. This report could probably be somewhat more valuable if such checking had been done. The fish managers in the several forests would do well to acquaint themselves with the method of growth determination ordinarily used and to check on the rate of growth of the fish in at least the more important lakes. (A binocular microscope would be satisfactory.) Only a very small number of specimens (fifteen or twenty of each important species) need be examined to get some idea of the rate of growth.



A sample of stunted and starved perch (in fifth year of life) completely removed from a lake shown by survey to have trout producing potentialities. Lake now yielding good annual crop of trout.

Introduction of trout is recommended rather frequently especially for the acid lakes in the Upper Peninsula. Trout seem to do reasonably well in acid water and it appears that these lakes which will support very few warm water fish because of infertility may support a reasonable crop of trout.

Natural reproduction of trout cannot be expected in land-locked lakes. Brown trout are invariably not recommended because of the apparent difficulty of catching them in lakes.

Some summary cards state that according to reports fishing was very much better in the past. For a while the writer felt that these comments were due merely to the fact that exceptional experiences were remembered while ordinary experiences were forgotten--that the old timer remembered the big hauls they made and forgot the many times that they took few fish.

It now appears that the old timers may be correct; that they took many more fish years ago (per angler) from some or most of these waters. If doubling the fishing intensity tends to halve the catch per hour, as suggested in the Fife Lake work, the poorer fishing now is probably due to an increased fishing intensity. In the poorer lakes especially, enough fish are possibly removed early in the season to temporarily disturb the balance between fish and food (in favor of the food), with poorer fishing resulting.

With many lakes in the Forests capable of supporting only a small poundage of fish, a rapid "turn-over" of the fish would be desirable; keep taking some out

so others have food. There is one drawback to this, however. The building up of the population of fish to a point where the "pasture" is again "grazed" to capacity may be too slow a process in northern lakes to permit a very rapid turnover.

A brief, superficial survey, such as the one made on the several lakes in the Forests, is of some value, but it should not be assumed that fishing in the lakes will be decidedly improved by following the suggestions made for the individual lakes. Until survey data can be more intelligently interpreted and until more basic facts have been uncovered, fish management must be regarded as strictly in its infancy and decidedly limited in its effectiveness.

It is believed, however, that periodic and preferably annual, examinations at least for the more important lakes of the area of growth rate, relative abundance of the species and size groups, and the take per angler, will indicate the trend of the fish population, and that a knowledge of this trend coupled with intelligent use of the management practices now available will tend to some degree to improve fishing conditions.

SPORT FISHING IS BIG BUSINESS

DEVOTEES OF Isaac Walton generated nearly $1,000,000,000 worth of business in the United States during this year, Charles E. Jackson, Acting Commissioner of Fisheries, estimated in a report to Secretary of the Interior, Harold L. Ickes. Sportsmen spent $877,309,009 for fishing licenses, tackle, photography, transportation, guides, food, lodging, bait, boats and other necessaries during 1938 according to a survey of their expenditures conducted by the Bureau of Fisheries. Some of the results shown were:

Expenditures for tackle and accessories made in the United States are estimated as $35,000,000. Creels of many descriptions and other articles under the title "tackle," as well as home-fashioned flies, rods, etc., are not included in that figure. Neither is live bait, which represents an industry of itself in several states.

License fees paid to the State Fish and Game Departments represent less than one-eightieth of the anglers' total expenditures.

According to reports, anglers in the State of Oregon paid $1,000,000 in gasoline taxes the past year. In Texas they spent an estimated $1,250,000 for gasoline; $2,500,000 for groceries, meals at restaurants, and accomodations at hotels; $1,000,000 for bait, boats, and guides; and $1,500,000 for clothing. Anglers at Freeport, Long Island, spent $1,000,000; and the trout fishermen at Apostle Island, Wisconsin, $75,000.

The total expenditures of the anglers in 1938 in Arizona was estimated at $959,550; California, $50,000,000; Indiana, $1,500,000; Maine, $41,171,441; Maryland, $1,500,000; Montana, $4,153,000; New Jersey, $1,000,000; New Mexico, $1,632,150; North Carolina, $1,000,000; North Dakota, $70,000; Oregon, $20,000,000; Rhode Island, $175,000; Texas, $12,500,000 (including hunters); Utah, $3,072,769 (including hunters); Vermont, $400,000; and Washington (all tourists, a large part of whom fish), $7,721,625. (From Press Release, Department of the Interior - November 1939.)

SOME EXPERIMENTS ON THE USE OF FRESH BEEF BLOOD AS A SUBSTITUTE FOR BEEF LIVER IN THE DIET OF YOUNG CHINOOK SALMON, (ONCORHYNCHUS TSCHAWYTSCHA)

By L. R. Donaldson
School of Fisheries, University of Washington
and
Fred J. Foster
U. S. Bureau of Fisheries, Seattle, Washington

BEEF BLOOD HAS been used as a food for young salmonoids for many years. In the fresh, cooked or dried form it has formed a portion of the diets fed to fish in many fish cultural stations. Evaluation experiments on the value of blood in fish diets apparently are lacking in the fisheries literature.

Feeding tests. This series of experimental feeding tests was carried on at the experimental hatchery of the University of Washington as a part of the cooperative program of the School of Fisheries and the U. S. Bureau of Fisheries. Young chinook salmon (Oncorhynchus tschawytscha) were used as test animals, with an initial 2,000 fish in each lot. The experimental feeding tests were started as soon as the fish had absorbed the yolk sac and were continued for 18 weeks . Four lots of fish were used in this series and a summary of results is given in tables 1, 2 and 3 and in figure 1. Each lot of fish was confined to a separate trough provided with fresh running water. The water temperature varied from 45° F. to 60° F. with the average at 51.1° F. during the experimental period.

The control lot, No. 1, was fed a diet of ground fresh beef liver. The fish in this lot were fed once a day and were given the amount of food they would "clean up" without waste.

The fish in lot No. 10 were fed a mixture of 40 per cent beef liver and 60 per cent salmon meal. The salmon meal used in all the diets containing meals was processed at the Quilcene station of the U. S. Bureau of Fisheries from the spawned-out carcasses of the chum salmon.

The fish in lot No. 11 were fed a diet of 40 per cent fresh beef blood and 60 per cent salmon meal. The beef blood used was fresh whole blood just as it was removed from the animal. By the time the blood arrived at the laboratory it had coagulated into a jellylike mass that could be mixed with the meal without further treatment.

The fish in lot No. 12 were fed a diet of 20 per cent beef liver, 20 per cent beef blood and 60 per cent salmon meal.

The fish in lots Nos. 10, 11 and 12 were fed mixed food to the amount of 35 per cent by weight of the liver fed to lot No. 1. For example, if the fish in the No. 1 lot consumed 100 grams of liver in a week, lots Nos. 10, 11 and 12 each received 35 grams of the mixed diets. The food mixtures fed to lots No. 10, 11 and 12 were of such a consistency that they could easily and efficiently be mixed

in the "blower type" of mixer. In feeding the fish in these lots a wire sieve of the appropriate mesh was used to size and scatter the food particles above the water in the troughs containing the fish.

Results: The rates of growth of the various lots of fish, as evidenced by the increase in average weight of bi-weekly weighed samples (table 1 and figure 1), show a decided uniformity in trend. The reduction of the food fed to lots Nos. 10, 11 and 12 to 35 per cent by weight of the amount fed to lot No. 1, fed beef liver, produced very uniform results. The fish in lots Nos. 10, 11 and 12 were actually given less food than they would have consumed if given all they wanted at their daily feeding.

The mortalities for the four lots, as shown in cumulative form in table 2, also present little in the way of extremes. Those fish that received a diet of 20 per cent liver, 20 per cent beef blood and 60 per cent salmon meal, lot No. 12 suffered the greatest mortality with the death of 313 of the original 2,000 fish, or 15.7 per cent. The liver-fed lot was second high with 270 (13.5 per cent), while the fish in lots Nos. 11 and 12, fed diets of beef liver and salmon meal, and beef blood and salmon meal respectively, experienced mortalities of 204 fish (10.2 per cent) and 241 fish (12.1 per cent) respectively.

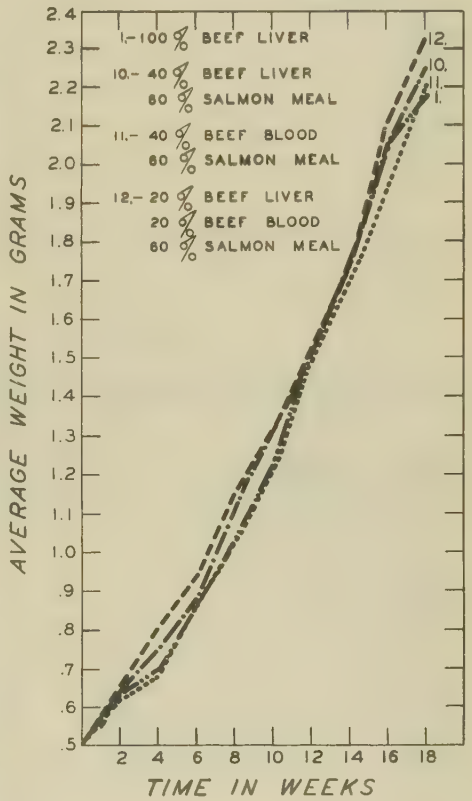


Figure 1.

In the cost of food to produce the fish there were significant differences. In computing food costs, liver was assumed to cost 5 cents a pound, salmon meal 4 cents a pound and beef blood 2 cents a pound. Lot No.1,fed beef liver, required 3.57 pounds of food to produce a pound of fish at a cost of $0.18.The fish in lot No. 10, fed 40 per cent liver and 60 per cent salmon meal required 1.16 pounds of food to produce a pound of fish at a cost of $0.051. Replacing liver with beef blood reduced the cost of food, since 1.22 pounds of of food, costing $0.039, produced a pound of fish in lot No 11, which received a mixture of 40 per cent beef blood and 60 per cent salmon meal. The fish in lot No. 12, fed 20 per cent liver, 20 per cent blood and 60 per cent salmon meal consumed 1.19 pounds of food to produce a pound of fish, at a cost of $0.045.

Conclusions: Fresh beef blood mixed with salmon meal, may be successfully fed to young chinook salmon. In food value the beef blood is not equivalent to beef liver but its availability at packing plants at a low price results in reduced food costs in relation to the weight of fish produced.

Table 1. Average weight in grams of chinook salmon fingerlings, based on samples weighed at two-week intervals.

	Lot Numbers			
	1	10	11	12
January 30 (Initial)	.5	.5	.5	.5
February 13	.64	.65	.62	.66
February 27	.69	.75	.68	.81
March 13	.85	.88	.86	.95
March 27	1.02	1.11	1.02	1.07
April 10	1.23	1.31	1.22	1.31
April 24	1.51	1.51	1.51	1.51
May 8	1.74	1.74	1.69	1.74
May 22	2.05	2.05	1.95	2.11
June 5	2.17	2.25	2.21	2.33

Table 2. Cumulative mortality numbers

	Lot numbers			
	1	10	11	12
Initial number of fish	2,000	2,000	2,000	2,000
February 13	99	72	60	117
February 27	151	121	99	153
March 13	186	150	121	200
March 27	213	163	145	239
April 10	224	177	166	272
April 24	242	186	202	287
May 8	251	192	217	294
May 22	260	198	224	300
June 5	270	203	241	313
Number of fish remaining alive	1,730	1,797	1,759	1,687

Table 3. Summary of experimental feeding tests with chinook salmon fingerlings at the University of Washington experimental hatchery

Experiment started: January 30, 1939. Concluded: June 5, 1939. Average water temperature 51.1° F.

	Lot numbers			
	1	10	11	12
Initial Average Length - Cms.	3.4	3.4	3.4	3.4
Average Length at report - Cms.	5.37	5.70	5.69	5.75
Per cent gain in length	57.9	67.6	67.4	69.1
Initial average weight-grams	.5	.5	.5	.5
Average weight at report- "	2.17	2.25	2.21	2.33
Per cent gain in weight	334	350	342	366
Condition factor	1.40	1.21	1.20	1.23
Mortality numbers	270	203	241	313
Per cent mortality	13.5	10.2	12.1	15.7
Total weight of foods fed-- grams	10,500	3,675	3,675	3,675
Efficiency factor	.28	.86	.82	.84
Lbs. of food to produce 1 lb. fish	3.57	1.16	1.22	1.19
Cost for food per pound of fish	$0.18	0.051	0.039	0.045

Diet: Lot No. 1 100% beef liver

Lot No. 10 40% beef liver
60% salmon meal

Lot No. 11 40% beef blood
60% salmon meal

Lot No. 12. 20% beef liver
20% beef blood
60% salmon meal

Cost of foods used:
Beef liver 5¢ per pound
Beef blood 2¢ " "
Salmon meal 4¢ " "

PRELIMINARY RESULTS OF AN EXPERIMENT ON THE INCLUSION OF APPLE FLOUR IN FOODS FED TO YOUNG SALMONOIDS

By Fred J. Foster, John Pelnar, William Hagen, Jr.
U. S. Bureau of Fisheries

EXPERIMENTS ARE being conducted in the Western District on the use of apple flour in the diet of young salmonoids to provide, primarily, bulk when the diet consists of high percentages of dried foods.

Preliminary results of such an experiment conducted at the Quilcene, Washington, station are of interest.

For a period of fifty-five days an initial number of 199,650 two and one-half inch silver salmon were fed the following diet:

	Per cent	Cost per Pound	Total Lbs. Fed	Total Food Cost
Flukey Beef Liver	50	$0.064	560	$35.84
Apple Flour	35	0.02	392	7.84
Salmon Carcass Meal	15	0.04	168	6.72
	100	$0.045	1,120	$50.40

Initial weight of the lot was 595 pounds and final weight 1,038 pounds; an increase of 443 pounds.

Total mortality for the period was only 870 fish.

To produce one pound of fish, 2.53 pounds of food were required, at a cost of $0.1138.

At least 20% of apple flour had been included in the diet of these fish for 105 days prior to the start of the experimental period, or since they first started feeding.

The apple flour used is a byproduct of the vinegar industry. The residue or pulp, which remains after the juice is pressed from whole apples, is dried. An approximate analysis of the product is as follows:

Protein	4.0%
Crude fat	4.5%
Crude fibre	12.0%
Ash, mineral matter	2.5%
Total sugar	22.5%
Carbohydrates, other than sugar and fibre	45.0%
Moisture	9.5%

This product is ground and passed through a 32-mesh screen. As the flour increases its size several times upon absorption of moisture, it is allowed to stand after being mixed with meats before being fed.

The analysis of the apple flour indicates that there is little food value in the product, the protein and crude fat being the only constituents of known value. Carbohydrates are known to be difficult for fish to assimilate. Thus, the inclusion of apple flour probably is of greatest value as a bulk.

If the 35% of apple flour included in the diet were not considered as a food, but merely as providing bulk, only 1.64 pounds of food were required to produce one pound of fish.

The fish used in the above experiment were fed as much as they would readily consume without waste. The inclusion of bulk in the diet was intended to preclude the dangers of overfeeding and the resulting degeneration of pancreas and

liver, even when a highly concentrated meal was fed. In the present case, all fish received a sufficient quantity of food as is indicated by uniform increases in size and weight of the fish in various ponds. Also, even after being fed a diet containing 50% of dried foods for 160 days, no evidence of "breaking" due to fattiness is expected.

Data indicates that apple flour, or some other suitable low cost bulk, is of definite benefit in the diet of young salmonoids.

THE REACTIONS OF SILVER SALMON, ONCORHYNCHUS KISTUCH, TO A 190 FOOT FALL

By Richard T. Smith
Washington State Department of Fisheries

EXPERIMENTS WERE conducted at Ariel Dam on the Lewis River, Washington, to ascertain the effect of a 190 foot fall upon silver salmon fingerling. The fish were tossed away from the crest of the dam to insure clearing the jutting base. The fish were dropped singly without water, and an attempt was made to recover each fish as it struck the pool below the dam. One hundred fish, 43 to 100 mm. standard length, were dropped in five experiments of 20, 15, 20, 20 and 25 fish, respectively. Controls were used for all experiments. Three fish of the first experiment, two in the third and one in the fifth hit solid objects (penstocks, etc.) and were instantly killed. Two fish were recovered from each of the experiments, except number 4, and these 8 recoveries, with their controls were held for observation periods of twelve days for those from number 1, and ten days for the others. There was no mortality among either the experimentally dropped fish or the controls during this period.

The falling fish usually vibrated their bodies rapidly as they fell, and the position of the body as it hit the water varied greatly. Fish hitting the water, either head or tail first, swam away at once, too rapidly to be captured. Those that struck the water with the body formed into an arc, so directed that the midsection was the point of impact, were usually somewhat stunned and the recoveries were entirely from these stunned fish. Recovered fish in two instances floated belly up in the recovery can for a time, but after five and fifteen minutes, respectively, were swimming normally. Another recovery swam with a rotary motion, but was swimming normally after three minutes. One stunned fish sank too rapidly to be captured, although it appeared to be recovering and a second evaded capture by spasmodic swimming. The remaining 82 fish swam away as soon as they hit the water.

The recovered fish ate well on the morning after they were dropped. They were easily excited for several days and would swim about rapidly when an observer approached the tank. The recovered fish, by presumption, were those that had experienced the most discomfort during the fall, and their survival indicates

that silver salmon of the sizes indicated can withstand falling into water from considerable heights. Falling in a stream of water would possibly be less stunning to the fish.

Acknowledgments: These experiments were performed incidental to the Washington State Department of Fisheries Lewis River Research Program. Thanks are due the officials of the dam for allowing the necessary freedom to conduct the experiments and to Walter Correll, of the Department's Hatchery Division, who aided in the experiments.

EFFECT OF TEMPERATURE CHANGES ON YOUNG TROUT

By Wm. Hagen, Jr.
U. S. Bureau of Fisheries

THE U. S. FISHERIES Station at Bozeman, Montana, is supplied with water from several cold springs having a constant temperature of about 48° F. and from a warm spring with a maximum temperature of 74° F. All water is piped to the hatchery building, and, inasmuch as the warm water is carried in a separate line, the water temperatures in the troughs may be varied as desired.

With the opportunity present to experiment with the effect of temperature on young trout, a number of simple experiments were outlined. In none of these was there given any special consideration to the feeding of the test animals; the usual quantity of food was given throughout the course of the experiments.

1. One hundred brook trout one and one-half inches in length were placed in a trough containing running water of 52° F. Warm water was turned into the trough, gradually raising the temperature, over a period of forty-eight hours, to 69.5° F. Flow of water was eight gallons per minute, as in all following experiments. Dissolved oxygen at the lower end of the trough was 6.3 p.p.m. at the higher temperature. There was no loss of fish for the first five days after the higher temperature was reached. During the next seven days, the mortality was five. Experiment discontinued.

2. Fifty brook trout one and one-half inches in length taken directly from water of 52° F. and placed in water of 69.5° F. There was no mortality for the first three days. During the next three days, fifteen fish died. Experiment discontinued.

3. Fifty of the trout used in the first experiment above were taken directly from the 69.5° F. water and placed in water of 52° F. There was no mortality for six days. Experiment discontinued.

4. Sixty rainbow trout one and one-half inches in length taken from 52° F. water and placed directly in water of 69.5° F. Loss of one fish on sixth day. Experiment discontinued seventh day.

5. Remaining rainbows (59) used in above experiment taken from 69.5° F. water and placed directly in water of 50.5° F. Loss of one fish on third day. Experiment discontinued fourth day.

6. Remaining rainbows (58) taken from water of 50.5° F. and placed directly in 72° F. water. No loss of fish for four days. Experiment discontinued.

7. Twenty-five one and one-half inch rainbows, twenty-five two inch albino brook trout and ten four inch Montana grayling were placed in separate compartments of a trough containing 52° F. water. The temperature was gradually raised to 74° F. in twenty-four hours by the addition of warm water and then was lowered to a constant temperature of 70° F. On the eighth day after reaching the latter temperature, one albino brook trout died, and on the ninth day eight more died. This was the total mortality for the three species for ten days when the experiment was discontinued.

It is probable that the losses among brook trout in the above experiments may be attributed to high temperatures.

These experiments indicate no great mortalities are to be expected from temperature changes within the ranges used in the above instances. The mortalities often attributed to temperature changes may possibly be due to a combination of chemical and physical conditions rather than the simple temperature factor.

In no case should information contained herein be interpreted as suggesting the discontinuance of tempering of fish before planting. It is probable that tempering, ostensibly for the purpose of equalizing temperatures, has eliminated sudden changes in carbon dioxide tension which, according to Powers (1937, Transc. Am. Fish. Soc.), may cause sudden mortality of fishes "by a derangement brought about by alternate compensation of the blood to higher and then to lower CO_2 tension of the water."

NATURALISTIC RACEWAYS

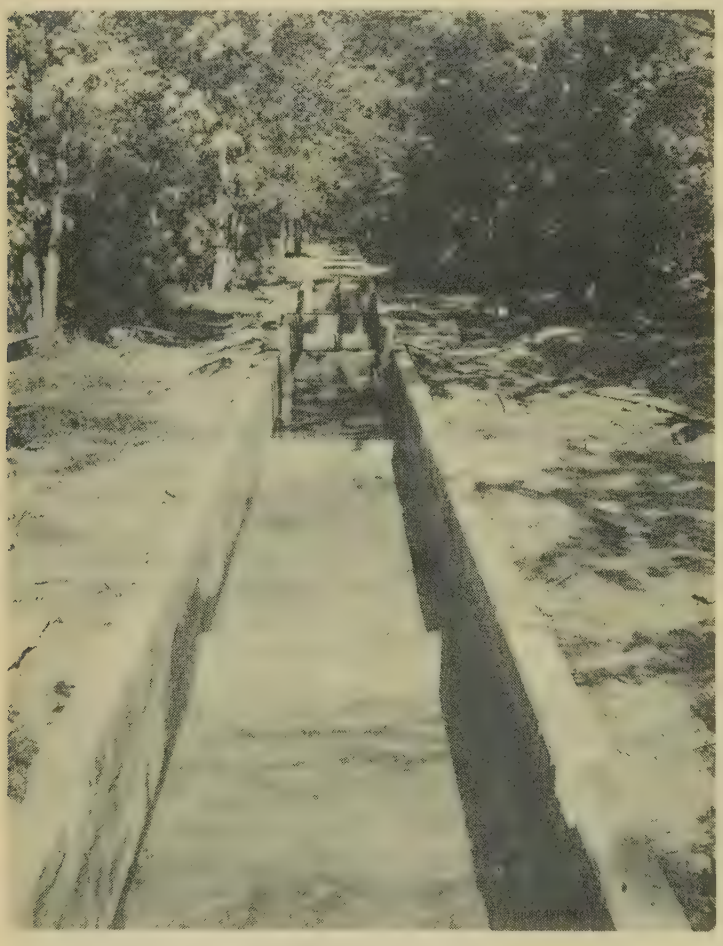
By Robert Fortney
District Supervisor of Fisheries Operation
Michigan Department of Conservation

WE USED TO have trouble raising trout in our raceways at Paris. That is, we had trouble up until fifteen years. ago. Losses were large and at last we decided to try to do something about improving the environment for the baby trout.

Our first experiment led us to believe that emulating nature could not lead us far astray, and holes and riffles were created by the means of 2 x 6 wooden dams. Gravel was packed on each side of the 2 x 6 and slightly over the top. The dams were so spaced that approximately 14 foot pockets were created with a depth of about 7 inches. It is surprising how the young trout will swim into

the riffle created by the dam and then drop into the quieter waters of the pool to rest. The exercise is good for the trout and keeps them healthy. It is almost unbelievable, too, how the young trout will segregate themselves in the pockets of the raceway. From one end of the raceway to the other, the population in each pocket is almost the same.

This summer we had an opportunity to rebuild our old raceway entirely out of concrete and steel. Even the dams were built out of concrete, reinforced with steel.



The raceway, as shown in the accompanying photograph, is 380 feet long and is divided into two sections to facilitate cleaning.

The upper section is 184 feet long, 4 feet wide (inside measurements) and is 2 feet 4 inches deep. There are eight dams in the upper section. The first dam at the head of the raceways is spaced 14 feet from the foot. The intermediate dams are spaced evenly in the remaining distance. The concrete dams are about 2 feet at the base and are lens shaped in cross section. This shape makes them easy to clean over, and, also the fish are less liable to be injured in passing over them.

The lower section is 195 feet long, 4 feet wide (inside measurements) and is 2 feet 4 inches deep. There are eight dams in the lower section and they are spaced the same as the upper section.

The raceway is covered its entire length by screen and shades. The shades are 8 feet long and 4 feet 8 inches wide. One shade is placed exactly over each pocket or pool and rests on the top of the raceway walls. The screens are 6 feet 3 inches long and 4 feet 8 inches wide and fill in the space between the shades.

At the age of three months baby trout are taken out of the hatchery and placed in the raceway.

During February, 1939, we carried 40,000 brown trout in the raceway and we have never reared more healthy nor more vigorous trout and the loss has been negligible.

REVIEWS

CONSERVATION IN THE UNITED STATES

By A. F. Gustafson, H. Ries, C. H. Guise, and W. J. Hamilton, Jr.
Comstock Publishing Co., Ithaca, New York, 1939; 431 pp., 232 figs.

THE WRITER recommends the book, CONSERVATION IN THE UNITED STATES, unreservedly to all fish-culturists. It contains, needless to say, no instruction in the art of raising fish, but it presents, clearly and interestingly, almost all aspects of the problem of conservation. This broad presentation is an effective antidote for the frame of mind which often develops in those of us who spend most of our time wrestling with the practical details of raising and stocking fish.

It is easy for us fish-culturists to fall into the habit of regarding our job as being just about the sum-total of conservation. If we do not fall into this error we, at least, think of our work as attacking one of its most fundamental problems.

CONSERVATION IN THE UNITED STATES makes vivid the fact that conservation of soil and water resources, and of forests, parks and grazing lands, which make up the subject matter of the first two sections of the book, are fundamental to the conservation of wildlife. The material in all these sections is up-to-date, accurate, and well presented. The illustrations are numerous and instructive.

In the section on conservation of wildlife, fish and fisheries are given much more attention than has been the custom in books of this sort. The hatchery foreman who is occasionally placed under the painful necessity of addressing a fish and game club will find in this section much authoritative material on the fishery situation in general.

In the chapter entitled "Fish and Fisheries" the sad story of the decline of shad, sturgeon, haddock, salmon, and halibut fisheries is brought to date. The reasons for the decline of our fisheries, salt water and fresh, are discussed at some length, after which there is an account of the conservation measures which are now being employed to combat the destruction of past years. The story of our shellfish, whaling industry, the fur-seal, and the sponge industry are also interestingly told.

In the chapter headed "Game and Fur Resources" the dreary record of the depletion of our wild animal life is told in graphic detail, and the reasons for the depletion are subjected to a thorough analysis. Although our past record in game conservation is shocking, the author does not allow his account to bog down in a slough of despair. The following statement is typical of the whole atmosphere of the section on wildlife.

"A new day is at hand for our wildlife resources. Public spirited citizens, legislators, hunters, trappers, game officials, and nature-lovers alike see the need of immediate conservation efforts if our birds and animals are to survive. Is it too late to save most of them? The answer is decidedly no."

To justify his optimism the author gives a detailed account of the conservation measures now being applied to save our wildlife. This includes a discussion of federal and state laws, national refuges, state preserves, restocking, introduction of new game species, fur farming, and game management. The new game management practices are given careful consideration.

There is a chapter entitled "Conservation of Other Useful Wildlife." In it the story of many of our lesser creatures is told, and their place in the "web of life" indicated. This chapter contains just the material needed to dampen the enthusiam with which many a fish and game club launches a misguided "vermin" extermination campaign.

A careful reading of this book should enable anyone to distinguish between fundamentals and the stop-gap activities which have received the major attention of local sportsmen's clubs, and even of many state conservation departments.

Louis E. Wolf

IS OUR FACE RED?

YOU KNOW HOW it is. We go along year after year doing the same old things in the same old way without stopping to consider whether the old way is right or whether it can be improved. The PROGRESSIVE FISH-CULTURIST also has been in a rut. It has followed Bureau of Fisheries practice established before 1880. Imagine our embarrassment therefore when we received a letter from Associate Editor Louie Wolf, pointing out a grevious error which The PROGRESSIVE FISH-CULTURIST has plastered all over its cover, its banner line, and throughout the text. His diplomatic criticism is phrased in the following gentle words.

"By the way, in Volume 68 of the Transactions of the American Fisheries Society, page 397, first line at top of page, it says that 'fish-culturist' should be written with a hyphen. Van Oosten (now the editor) is a bad man to monkey with, as anyone knows who has ever got a manuscript back from him. I am afraid he will jump us if we do not comply."

Since the decision of the Editor of the Transactions is confirmed by Webster's Dictionary and the Government Printing Office Style Manual, we hasten to comply, but, habit being what it is, we hope you will forgive a few slips until we get into the swing. - Ed.

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